Rocky Mountain Forest and Range Experiment Station

RESEARCH HIGHLIGHTS 1966

ANNUAL REPORT

Forest Service
Raymond Price, Director

U.S. Department of Agriculture
Fort Collins, Colorado

PROJECT LOCATIONS

Albuquerque, New Mexico
New Federal Building

Bottineau, North Dakota
Shelterbelt Laboratory

Flagstaff, Arizona
Forestry Sciences Laboratory
Northern Arizona University

Fort Collins, Colorado
Forestry Building
Colorado State University

Laramie, Wyoming
Forest Range and Watershed Laboratory
University of Wyoming

Lincoln, Nebraska
Plant Industry Building
University of Nebraska

Rapid City, South Dakota
Forestry Sciences Laboratory
South Dakota School of Mines
and Technology

Tempe, Arizona
Forest Hydrology Laboratory
Arizona State University

Tucson, Arizona
Tumamoc Hill
University of Arizona

Station headquarters is at Fort Collins, Colorado,
in cooperation with Colorado State University

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

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March 1967

Contents

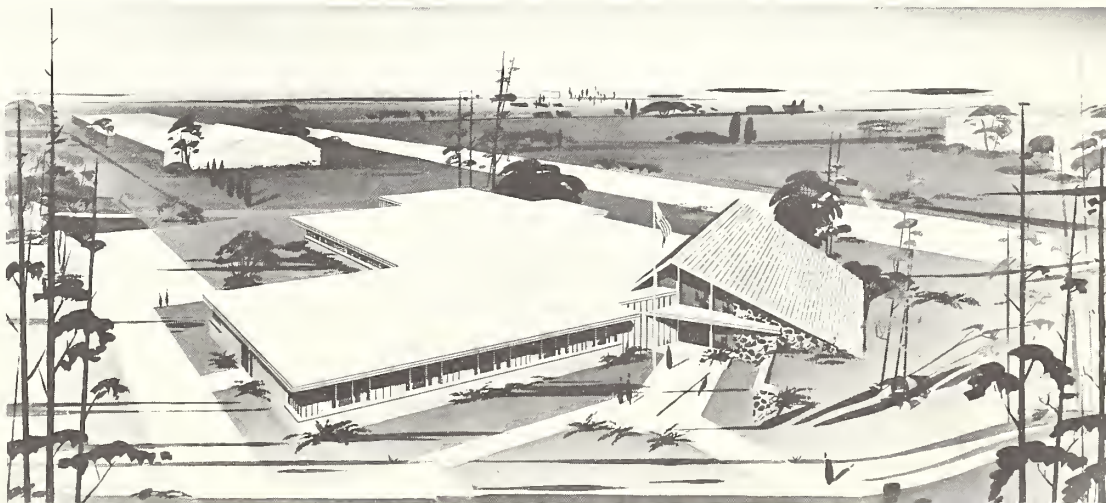
A brief summary

To increase the efficiency of Forest Service Research nationally, the area served by the Rocky Mountain Station was expanded to include North Dakota. The Station now has responsibility for all shelterbelt research for the Forest Service, including the Shelterbelt Research Laboratory at Bottineau. This move will facilitate coordination of the shelterbelt establishment and management projects for the Northern Plains, located at Bottineau, and for the Central and Southern Plains, located at Lincoln, Nebraska.

Timber Management Research continued to emphasize regeneration of southwestern ponderosa pine, spruce-fir, and mixed conifers, but is shifting to management procedures and tree improvement in Black Hills ponderosa pine and Great Plains shelterbelt projects.

Seeds of ponderosa pine germinated well under low and medium moisture stress and grew well when the stress was reduced. Seeds germinated poorly under high moisture stress and never grew well, even after moisture stress was reduced. When germination of spruce seeds is delayed until midseason, the seedlings rarely survive. Spruce seedlings planted in full sunlight suffer more from snow mold fungus than seedlings planted in partial shade.

Natural reproduction of spruce-fir was found to be generally good on small clearcuttings. A mixed conifer seed crop of nearly 740,000 seeds per acre of uncut timber cast an average of only 10,000 seeds per acre to the center of a 10-acre unit. 1-0 and 2-0 seedlings of ponderosa pine survived as well as



The Shelterbelt Research Laboratory at Bottineau, North Dakota, was added to the Rocky Mountain Station to better coordinate shelterbelt research.

1-1 and 2-1 transplants in 2 years of above-average moisture in the Black Hills.

Site indexes developed for lodgepole pine are applicable to the whole West. Aspen site indexes are accurate for stands 40 years old and older. Yield tables for managed stands have been completed for ponderosa and lodgepole pines. A heavy second thinning in Black Hills ponderosa pine produced an extraordinary growth response.

Provenance tests showed that eastern Montana ponderosa pine and Utah blue spruce have done especially well in the northern Plains.

For Forest Fire Research, we have prepared a test burning area in chaparral, and equipped it with instruments, including a mobile laboratory. Chaparral foliage dried with 2,4,5-T in oil was found to contain more heat energy than untreated leaves.

Forest Insect Research continued to stress natural control of damaging insects, with some added emphasis on attraction. Female spruce budworms produce a powerful sex attractant. Three species of flycatchers that inhabit the high mountains feed abundantly on spruce budworms. The single-year life cycle of a ponderosa pine budworm was learned in considerable detail. In our continuing search for nematode parasites of bark beetles, we identified two new species of internal parasites and nine new species that are associated with bark beetles. Two predaceous insects, the red-bellied clerid beetle and the fly, Medetera aldrichii, consume significant numbers of Black Hills beetles and their larvae.

In Forest Disease Research, major emphasis continued to be placed on the taxonomic revision of the dwarfmistletoes (genus Arceuthobium), and significant new information was gathered on the distribution and hosts of these serious parasites of western conifers. Silvicultural "recleaning" of an infected stand of ponderosa pine cost more than the original cleaning treatment. Antibiotic tests started in 1960 were terminated with the conclusion that neither Acti-dione nor Phytoactin were effective in controlling western gall rust and several canker diseases of aspen. Basic taxonomic studies of needle diseases of conifers revealed additional pine hosts of Hypoderma mexicanum in Mexico. Data from about 1,000 merchantable trees provided good evidence that external indicators can be used to estimate cull in Engelmann spruce.

Red rot was found to affect 15 percent of the gross volume of virgin ponderosa pine on the Navajo Indian Reservation, and to be increasing at the rate of one-half percent per decade. Excellent control of a serious disease of pines on the Great Plains, Dothistroma needle blight, was obtained with two applications of Bordeaux mixture.

Range Management and Wildlife Habitat Research was expanded on deer habitat management in the Black Hills of South Dakota. In Wyoming, sheep distribution, forage utilization, and animal weight gains were compared for two bands of sheep on alpine ranges--one band was herded, the other was not. Other research continues to explore fundamentals of plant and animal ecology, and the relationship of land treatments to range forage production and quantity of wildlife habitat.

Because of marked differences in time of soil-moisture use by perennial grass, annual grass, and burroweed, a major segment of available soil moisture apparently is not being put to beneficial use on semidesert grass-shrub ranges. Studies were therefore started to learn how to substitute good forage species for the noxious burroweed. Unless this substitution can be made, burroweed soon becomes reestablished after control. Also, in Arizona, blue grama production was found to be suppressed by the occurrence of broom snakeweed, a widespread, unpalatable half-shrub. Guides developed for burning individual trees of nonsprouting junipers show that too much burning of a tree can be unnecessarily expensive, whereas too little burning is not effective. In Colorado, seeding big bluegrass was found to extend greatly the green forage period on ranges in the Front Range, making possible increased calf weight gains.

Current findings in wildlife habitat and forest biology indicate that there may be a phosphorus deficiency in chaparral shrubs in

the Southwest during the period of heavy shrub use by deer. Other studies showed that wet meadows in the Southwest produce large amounts of nutritious forage important to deer and elk. In both the Southwest and in the Black Hills, age and stand structure of ponderosa pine forests were found to influence their use by deer. Merriam's turkeys prefer mature ponderosa pines with limbless lower trunks and relatively large and widespreading limbs for roost trees. Turkeys were found to use a wide variety of plants for forage and mast. On National Grasslands, stock ponds appear to offer considerable potential for waterfowl production.

In western Colorado, pocket gopher numbers were found to be unrelated to grazing intensity on Thurber fescue ranges after 10 years of grazing at three different intensities. Meadow voles were so few on these ranges as to be relatively insignificant.

Watershed Management Research continued to emphasize isolating those factors within a watershed that have the most promise of improving the timing or increasing water yields and reducing sediment. How wind transports snow and how it is deposited in forest openings is a major study. We are cooperating with the U.S. Bureau of Reclamation on the influence cloud seeding has on streamflow, and whether or not induced snowfall can be detected in increased runoff. Increased effort is being given to the control and methods of forecasting avalanche dangers that are ever present as our mountain areas receive greater public use.

A third treatment has been started on the North Fork of the Workman Creek watersheds in Arizona. Approximately one-half of the better ponderosa pine will be removed from the watershed, which should provide needed information on how clearcutting high-quality ponderosa pine affects yields of water and sediment. On the South Fork of Workman Creek, the present stand will be harvested to a basal area of approximately 40 square feet per acre of pine. This treatment will provide data on the effect on water yield of converting a watershed to managed stands of ponderosa pine.

Good progress has been made on geomorphological studies in the Black Hills, which will provide a basic understanding of how snow cover, soils, plants, topography, geologic formation, and climatic conditions function to influence water quality, quantity, and timing.

Measurements of gross beta activity in snowmelt water indicate that forested watersheds and mountain bogs remove and retain radioactive particles. Good progress has been made in assessing the effect of different concentrations of fenuron on chaparral vegetation, and its rate of loss from the soil.

Work is continuing on methods for measuring transpiration from watershed vegetation. Plants of all sizes and under varying conditions are being studied in an effort to gain a better understanding of the role transpiration plays in total water yield from a watershed. Once this is known, we can try to control transpiration with chemicals and other means to improve water yield.

Forest Economics Research continued the watershed evaluation work at the Beaver Creek pilot watershed area in north central Arizona. Analytical methods are being developed for the multiple use and economic evaluation of alternative watershed management practices. Parametric linear programming is being tested as one of the new analytical techniques capable of handling the large amounts of complex data being generated. The studies have progressed to the point that some of the calibrated watersheds are being treated to determine the potential for additional streamflow. One watershed, covered mostly with alligator juniper, has been cleared of all vegetation. Another, in the ponderosa pine forest area, has been cleared of merchantable timber, and the remaining trees and slash have been windrowed.

The north- and east-facing slopes of ponderosa pine forests in northern Arizona are best for trapping winter snows for spring runoff. From studies of strip cuttings in the forest, promising combinations of strip widths and slope aspects will be tested.

When the basal area of timber is less than 70 square feet per acre, the forest that has

been thinned produces more herbage (grasses, forbs, and so forth) than does one that has not been thinned. Thus we cannot predict the effects of thinning on herbage yields by observing the herbage in unthinned areas.

Forest Recreation Research looked at campground use and costs of building and operating campgrounds. Campgrounds located near lakes and streams are most popular, but use of a campground was found to be not affected by its location in relation to other campgrounds, urban areas, elevation above sea level, or surfaced highways. In Colorado, campgrounds near highways are favored by out-of-State visitors, but Coloradoans make about equal use of back-country camps and those near the highways.

Travel trailers and tent trailers were used by 41 percent of all campers sampled in 1965. Seventeen percent used pickup-campers, and 38 percent used tents. Groups with tent and travel trailers tend to use near-highway camps more than back-country areas.

Preliminary results of interviews with over 650 people who were fishing, camping, or generally relaxing in a popular mountain canyon indicate that most of these visitors prepared for their recreation trip at home, brought most of what they needed with them, and spent little money at businesses located in the canyon itself.

Forest Products Marketing Research initiated the first in a series of studies of plywood market potential. Data on production and shipment of softwood plywood throughout the entire United States have been analyzed. A total of 12.4 billion square feet of plywood (3/8 inch equivalent basis) was produced in 1965. Eighty-seven percent was made in West Coast plants, 3 percent was produced in the South, and 10 percent came from mills in the Inland and Mountain West. This plywood has been traced through shipments to 494 trade area destinations throughout the country.

Forest Products Utilization Research continued to concentrate on improved utilization of the region's timber resources, and development of new products for western softwood species.

Early results of a test of treated and untreated fenceposts of Black Hills ponderosa pine showed that untreated posts begin to decay and fail within only 5 years when placed in moist sites. Continued comparisons of an experimental solar-heated lumber dryer with customary open air drying have demonstrated that the solar dryer does a better drying job faster, especially during cold or wet weather.

Study of ponderosa pine trees in the Southwest has confirmed the importance of lean in influencing formation of compression wood, but it also has shown that a growth response to release, when nearby trees are cut, causes a substantial increase in compression wood in leaning trees.

Samples taken from over 400 southwestern ponderosa pine trees have been analyzed to show that resinous materials in the wood cells ("extractives") are important causes of variation in specific gravity of ponderosa pine wood. The specific gravity of the wood itself is an indicator of the wood's strength and of its potential cellulose yield. Variations due to the extractives may cause inaccurate estimates of strength or fiber yields.

Stem-form characteristics of trees are important factors affecting suitability of the trees for use in various products. Data from cutover ponderosa pine stands in Arizona show that crook, sweep, and lean are the most common stem defects.

Details of these and other findings are presented in the following pages. Complete accounts of our research are released through various publications. An annotated list of publications issued in 1966 is included in the bibliography at the end of this report.

Raymond Price, Director

Timber Management and Forest Protection Research

Timber Management

Westwide site indexes developed for lodgepole pine

Height-over-age curves have been prepared for rating the productivity of even-aged lodgepole pine[1] stands Westwide, in cooperation with the Intermountain and Pacific Northwest Forest and Range Experiment Stations. The curves express heights of dominant trees for total ages.

[1] *Common and scientific names of animals and plants mentioned are listed inside the back cover. Those for diseases and insects are included in text since many are identified only by their scientific names.*

Because height growth of lodgepole pine is restricted when the trees are crowded, site index determined from height-over-age curves must be adjusted for stand density. In this study, density was expressed as Crown Competition Factor (CCF). For stands where the CCF was 125 or less, height growth was unaffected by density, and site index was simply the expression of the relationship of height growth to site quality and age (fig. T-1). For stands where CCF was greater than 125, height growth was reduced; the greater the CCF, the greater the reduction; and the higher the site quality, the greater the reduction. To determine site index in stands where CCF is greater than 125, height-over-age curves similar to those in figure T-1, but adjusted

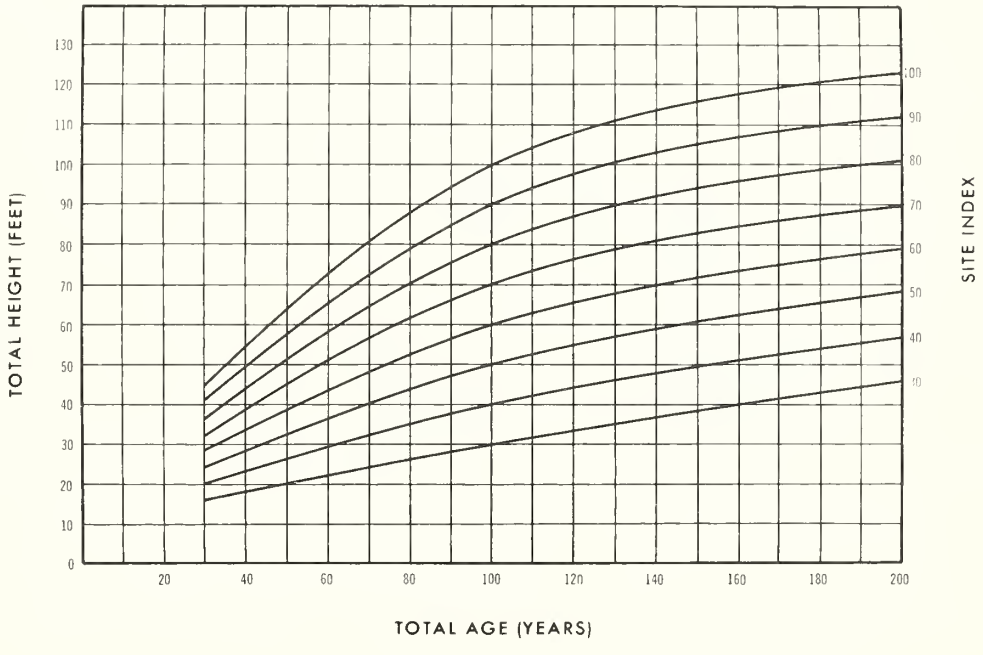


Figure T-1.--Site index curves for even-aged lodgepole pine, CCF 125 or less.

for the reduction in height growth due to density, were prepared for CCF 200, 300, 400, and 500.

Moisture stress reduces germination and growth of ponderosa pine seedlings

Amount of moisture stress, induced by the use of Carbowax 400, influenced both germination and growth of ponderosa pine seed. Three pretreatments--wetted and dried five times, soaked in water 24 hours, and air dried (check treatment)--did not significantly alter the rate or proportion of seeds that germinated under the various moisture stresses.

Seeds germinated at moisture stresses of 0, 3, 7, 11, and 15 atmospheres (atm.) were transferred to vermiculite-filled glass tubes and watered with combinations of Hoagland's and Carbowax 400 solutions. One-half strength Hoagland's solution provided uniform nutrient supplies. Carbowax 400 was added to get the same five moisture stresses used for germination.

Seeds germinated most rapidly at low moisture stresses (fig. T-2). Fifty percent of total germination was reached in 7 days under 0 and 3 atm. of stress, but took 15 days under 15 atm. Total germination did not differ greatly (70 to 80 percent) among 0, 3, and 7 atm. of stress, but dropped to 25 percent in 15 atm.

At the end of an 18-day growing period, root penetration, cotyledon length, and dry weight of roots were all significantly influenced by moisture stress, both during germination and subsequent growth in the nutrient solution. Seedlings germinated at 15 atm. of moisture stress did not recover and grow, even when watered with 0- and 3-atm. solutions. Also, seedlings germinated at low moisture stress did not grow well in solutions of 7 atm. stress or more. Best root penetration (16.7 cm.) was made by seedlings that germinated and grew in the 0-atm. moisture stress treatment.

Climatic and biotic conditions influence artificial regeneration of conifers

The following are some of the lessons learned from planting and seeding experiments with Engelmann spruce and lodgepole pine on the White River Plateau in western Colorado:

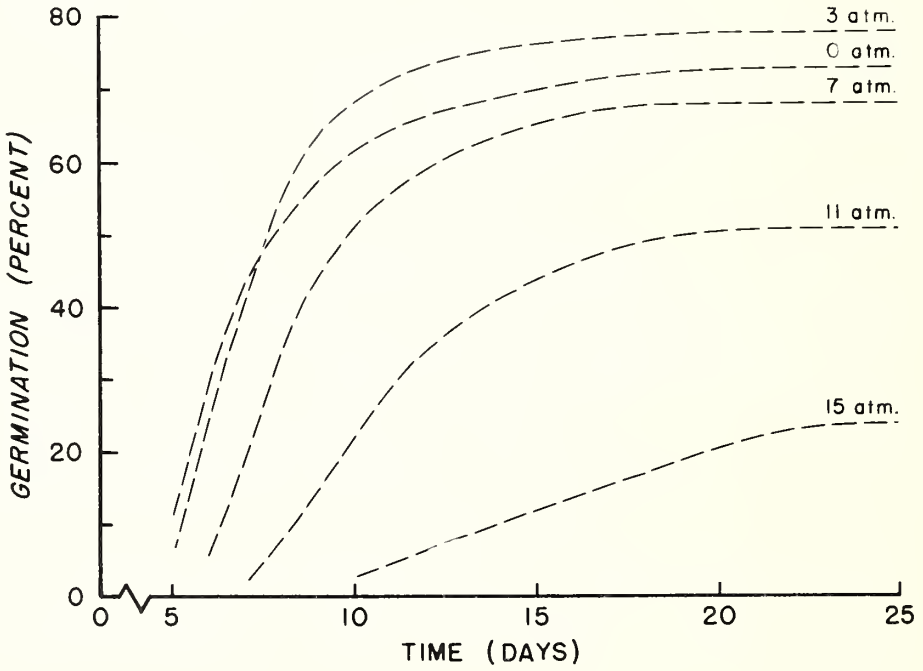


Figure T-2.-- Germination of ponderosa pine seeds at various moisture stresses. Moisture stresses are expressed in atmospheres (atm.) of osmotic pressure of solutions used to germinate the seeds.

Planting

1. Pine survived better than spruce when planted in full sunlight.
2. Shading improved survival of spruce, but had no influence on pine.
3. Shading reduced damage to spruce from late-spring frosts. Pine was not damaged by frost.
4. Snow mold fungus attacked more open-grown spruces than pines or shaded spruces.
5. Spruce and pine plantations that had survived several growing seasons were destroyed in 1 winter by mountain pocket gophers.

Seeding

1. Direct seeding of Engelmann spruce always failed.
2. Prompt germination, which happened only when moisture was plentiful, was essential to success in seeding pine.
3. Lack of late-spring or early-summer precipitation either delayed germination of pine, or kept many of the seeds dormant until the following spring. Late-germinating seedlings did not harden off properly, and were not able to survive over winter. Seeds that remained dormant over winter were exposed to increased depredation from rodents.
4. Newly germinated seedlings suffered heavily from damping-off, mice, and frost heaving. Nearly two-thirds of all mortality in 3 separate years was caused by those agents.
5. Best results were obtained when scalped seedspots were shaded with a shingle, and mulched with sawdust.

Pattern of mixed conifer seedfall on a clearcutting in Arizona

At Burro Mountain on the Apache National Forest, an uncut mixed conifer stand released 739,000 filled seed per acre in 1964. The species were Engelmann and blue spruces, Douglas-fir, corkbark and white firs, southwestern white pine, and ponderosa pine.

On a nearby 10-acre clearcutting, the seedfall averaged more than 400,000 seed per acre only within about 1 to 1.5 chains of the upwind timber margin (which was also the upslope margin), but much less along other margins (fig. T-3). Within a 1.6-acre central area, defined by the 40,000-seed-per-acre isoline, seedfall averaged only about 10,000 per acre.

Four classes of planting stock survive well in Black Hills

Four classes of ponderosa pine planting stock (1-0, 2-0, 1-1, 2-1) survived well on both favorable and "marginal" sites after planting in 1962 and 1963 (fig. T-4). Since precipitation was above average both years, the tests were not severe; results can be considered applicable only to favorable years.

The small 1-0 trees were difficult to handle and plant properly. They have grown less than

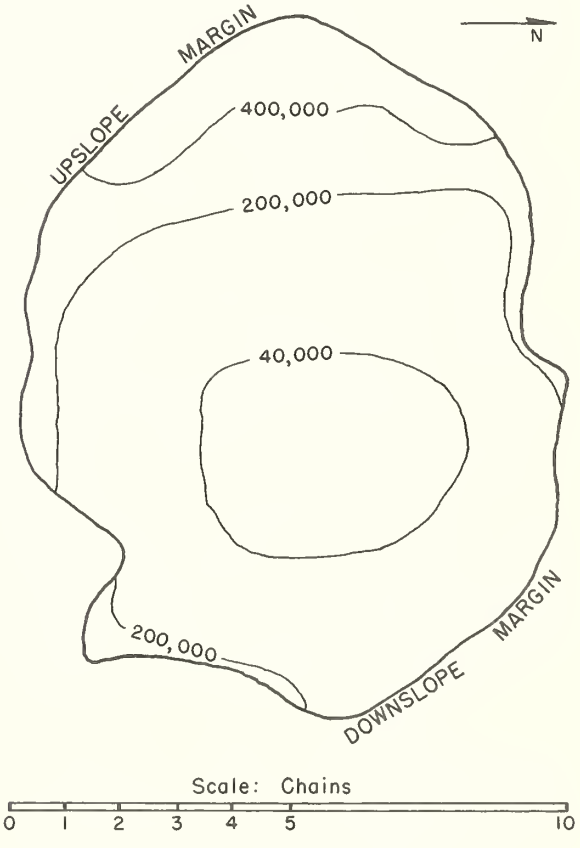


Figure T-3.--1964 fall of filled seed per acre on a 10-acre clearcutting.

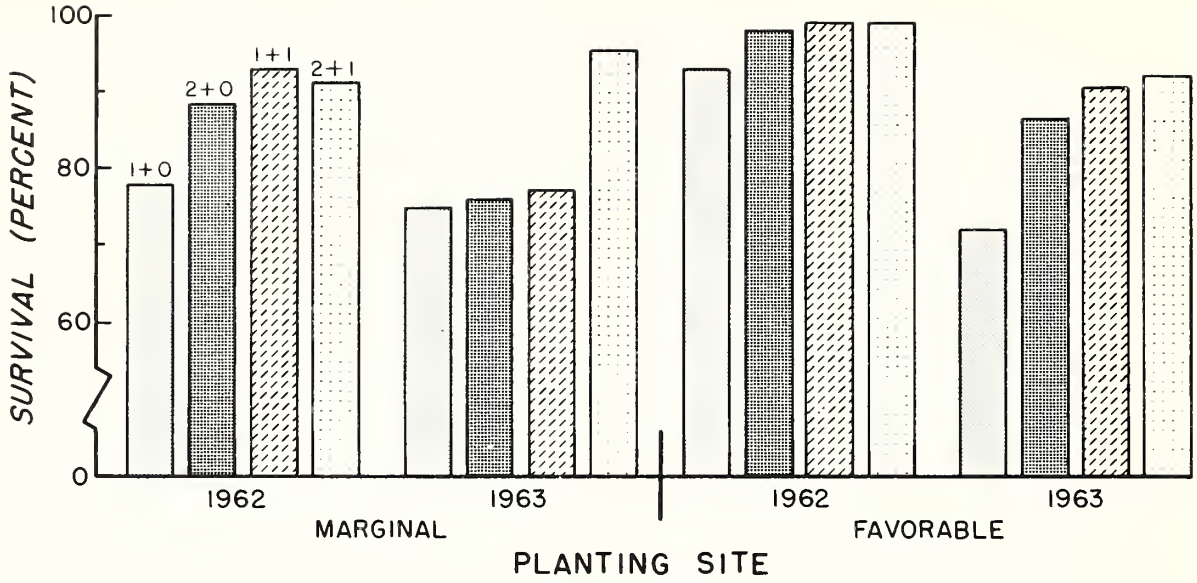


Figure T-4.--Average rates of third-year survival for four classes of ponderosa pine stock planted on two Black Hills sites in two different years.

the older stock, and do not appear to compete with other vegetation as well. In view of the costs, survival, and other factors, 2-year-old seedlings or transplants are recommended for general planting in the Black Hills.

Aspen site index estimotes relioble except when bosed on young stonds

A new site index table for aspen was made from natural site index curves, based on an index age of 80 years. The natural curve for each site index class was based on stem analysis of trees on plots belonging in that class.

Even within a class, actual height growth curves differed in shape on different plots. The resulting errors in estimating true site index are usually small in stands of age 40 or older, but reliability is low when 30-year-old stands are used. Twenty-year-old stands give very unreliable estimates.

Reproduction good on smoll cleorcuttings in spruce-fir in Colorodo

Eighty-three percent of 1/300-acre sample plots were found to be stocked on eight sale areas where timber was harvested by commercial clearcuttings in alternate strips 200 to 400 feet wide. About two-thirds of the 1,748 sample plots were stocked with fir, and more than half were stocked with spruce. Advanced reproduction stocked 61 percent of the plots, and subsequent reproduction stocked 54 percent. Advanced reproduction was predominantly fir, but subsequent reproduction was evenly distributed between spruce and fir (fig. T-5).

Composition and abundance of subsequent reproduction was related to several observed environmental conditions and cutting unit characteristics. Conditions where stocking to subsequent reproduction was above and below average are shown in table T-1. Stocking averaged 38 percent for both spruce and fir.

Ponderoso pine stonds heovily infested with dworfmistletoe should be cleorcut

Three cutting treatments were applied in virgin ponderosa pine on the Fort Valley Experimental Forest during 1951-54, with a retreatment in 1958. One treatment was designed for complete control, one for partial control, and the third was the light improvement-selection cutting used widely in the Southwest.

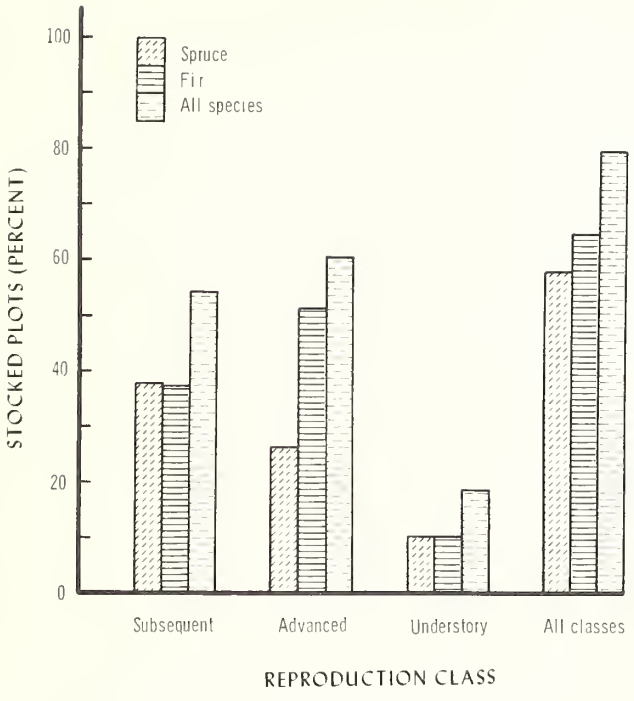


Figure T-5.--Average stocking by species and classes of reproduction.

Dwarfmistletoe infection of the merchantable volume was reduced markedly by both the partial and complete control treatments, but increased on stands cut by light improvement-selection. The control treatments, however, reduced merchantable volume from more than 11,000 to about 2,800 board feet per acre, and left half of the area unstocked. Part of the volume reduction resulted from heavy windthrow damage in 1957 in the partial and complete control plots.

We have concluded that heavily infected sawtimber and pole stands should be clearcut. Lightly infected stands should be treated to remove infected sawtimber and pole-sized trees. Small poles and saplings with dwarfmistletoe in the main stem should be removed; infected branches in the remaining trees should be pruned away.

Yield tables for managed stands

Like other managers, foresters should forecast the probable benefits from their activities before the jobs are started. With tim-

Table T-1.--Stocking of subsequent reproduction and its relation to environmental factors and cutting-unit characteristics

Characteristics of area	Engelmann spruce		Subalpine fir	
	Average or above	Below average	Average or above	Below average
Seedbed	Disturbed and skidroad	Undisturbed	Undisturbed and disturbed	Skidroad
Ground covered with slash	Less than 40 percent	40 percent or more	Less than 40 percent	40 percent or more
Aspect	N, NE, E, W, NW	SE, S, SW	N, NE, E, W, NW	SE, S, SW
Average density of ground vegetation	Medium to heavy	Light	Medium to heavy	Light
Slope	Above 25 percent	25 percent or less	Above 25 percent	25 percent or less
Length of time since areas cut	6-7 years	3-4 years	4-7 years	3 years
Relation of cutting unit to contour	At right angles	Parallel	Parallel	At right angles
Width of cutting unit	200 feet	400 feet	400 feet	200 feet
Soil texture and derivation	Light textured, derived from sandstone	Light textured, derived from granitic rock; and medium textured, derived from various parent materials	Light textured, derived from sandstone	Light textured, derived from granitic rock; and medium textured, derived from various parent materials

Table T-2.--An example of predicted yields from managed stands:
Yields per acre of managed, even-aged stands of lodgepole pine in Colorado and Wyoming.
Site index 70, 30-year cutting cycle

Stand age (Yrs.)	Entire stand before and after thinning							Periodic cut				
	Trees	Basal area	Average d.b.h.	Average height	Total volume	Merchantable volume	Sawtimber volume	Trees	Basal area	Total volume	Merchantable volume	Sawtimber volume
	No.	Sq.ft.	In.	Ft.	Cu.ft.	Cu.ft.	Bd.ft.	No.	Sq.ft.	Cu.ft.	Cu.ft.	Bd.ft.
10	2,000	4	0.6	7								
30	1,550	110	3.6	28	1,550							
30	458	53	4.6	28	760			1,092	57	790	0	0
60	448	137	7.5	47	3,250	2,630						
60	260	91	8.0	47	2,150	1,820		188	46	1,100	810	0
90	258	158	10.6	62	4,920	4,590	14,100					
90	149	100	11.1	62	3,120	2,920	9,900	109	58	1,800	1,670	4,200
120	149	155	13.8	72	5,590	5,330	23,400	149	155	5,590	5,330	23,400
Total								1,538	316	9,280	7,810	27,600

ber crops, one benefit to be forecast is the amount of useful wood produced by each of the possible alternatives of management. Production data are assembled in yield tables that show growth and production on an acre managed according to certain standards. It is quite easy to create these tables from repeated measurements of managed stands. The difficulty is that these yield tables are needed before the managed stands can be created and measured repeatedly.

A procedure for preparing yield tables from stands measured once has been developed. Data from numerous stands are used to prepare equations and tables that predict the growth of stands managed under a wide variety of alternatives. Yield tables and prediction tools for ponderosa pine were published recently in Research Paper RM-21. Tables and prediction tools for lodgepole pine have also been prepared. Table T-2 shows, as an example, the large amount of useful information available in these yield tables.

How many trees make a full stand?

"Overthinned and understocked" is how many foresters would rate the stand of widely spaced ponderosa pine poles in figure T-6. In 1965, however, the first year of growth after a second thinning, diameter increased an average of 0.37 inch and basal area 3.34 square feet, compared to 0.14 inch and 4.15 square feet in 1964. One-fourth as many trees produced 80 percent of the 1964 increase in basal area. Such remarkable growth suggests that (1) repeated thinnings may stimulate substantially better growth than single thinning, and (2) repeat thinnings can be heavier than first thinnings.

The good response is attributed to (1) removal of three-fourths of the trees and two-thirds of the basal area, which left only the cream of the growing stock, and (2) the trees' reaction to the first thinning, 7 years earlier, which enabled them to respond promptly and strongly to the second thinning.

Trees of local origin grow best at Fort Valley, Arizona

Of 19 different provenances of ponderosa pine planted at Fort Valley Experimental Forest from 1913 to 1917, parts of 11 still survive. Trees from eastern and southeastern parts of the species range have survived up to 40 percent. Trees from northern and western sources generally failed. Although they ap-

Figure T-6.--
Black Hills ponderosa pine stand thinned to 105 trees and to 34.5 square feet of basal area per acre.

peared larger and healthier at the Fort Valley nursery than other sources, they were unable to withstand the frost and drought.

Ponderosa pines from sources closest to Fort Valley grew best. Trees from the Coconino and Manti-La Sal National Forests are largest. Coconino source trees formed straighter stems and began leader growth later in the spring than trees from the central Rocky Mountains and Black Hills.

Insects and unfavorable weather were the major causes of mortality during the early years. Weather was favorable in 1913 and 1914, but the May beetle larvae killed many seedlings of all sources. Hard freezes in the fall of 1916 killed all the Angeles and Klamath National Forest seedlings and nearly all of the Tahoe seedlings while still in the nursery. A severe fall drought in 1917 eliminated 6 of the 14 sources planted the preceding spring.

Ponderoso pine from eostern Montona perform well in North Dokota

Ponderosa pines from western Montana, eastern Montana, the Black Hills of South Dakota, and western Nebraska were planted extensively on dune sands at the Denbigh Experimental Forest in north-central North Dakota from 1933 to 1944. After 25 to 30 years, trees from eastern Montana seed sources rank first in survival, height, and diameter growth. In addition, these trees have grown the coarsest branches and densest foliage, and have shown resistance to winter desiccation.

Until results of current research on the adaptability of ponderosa pine seed sources to the Great Plains are available, seeds from eastern Montana are recommended for North Dakota shelterbelt plantings.

Blue spruce from Utoh grow well in North Dakoto

Blue spruce, an introduced conifer, has performed well in shelterbelts in the Northern Great Plains. The seed origins of most trees in established plantings are unknown. To test the growth, survival, and tolerance of the climate, trees from seven known locations from northern Arizona to northern Wyoming were planted in north-central North Dakota in 1961.

After 5 years, survival ranged from 22 to 96 percent, and total heights from 1.2 to 1.9 feet. A Utah source was best in both respects, and also expressed superior resistance to late spring frost damage.

These early results suggest that the best seed sources for planting in the Northern Prairie-Plains may be found in limited, rather than broad, collection zones.

Cultural treatments used to repair damaged shelterbelts in Nebraska

To repair a shelterbelt that was losing effectiveness, four remnant rows of trees were removed by felling, the ground between the rows was plowed, and four rows of conifers were planted in 1963. Five cultural treatments have been used since to keep weeds down. Preliminary conclusions are:

1. Complete mechanical cultivation appears excellent at this time for establishment, subsequent growth, and survival of seedlings (fig. T-7).
2. Chemical spray (Simazine, 4 pounds per acre) over the whole area is fast, and seems promising for conserving soil moisture (fig. T-7).
3. Complete mowing of weeds seems to be satisfactory and relatively fast, but may permit moisture losses during the establishment phase, which could be detrimental during droughty years.
4. Chemical and mechanical strip treatments both appear unsatisfactory because of excessive moisture loss during the growing season from adjacent weeds, excessive shading by weeds in summer, damage to seedlings from snow piling in winter, harboring of rabbits and mice during winter, cluttering of rows with fallen weeds, and concentration effects of chemicals within the rows following heavy rains (fig. T-8).

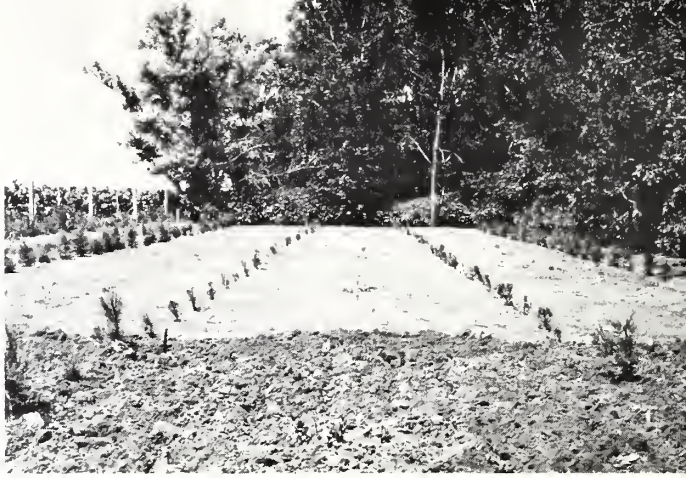


Figure T-7.--Complete cultivation (foreground) and chemical spray (background) were good cultural treatments for new conifer rows in a shelterbelt.

Figure T-8.--Strip treatments, either mechanical or chemical, were not satisfactory for various reasons.

Forest Fire

Chaparral area readied for prescribed burning treatments

A 40-acre area of mixed shrub live oak and manzanita 30 miles east of Prescott, Arizona, is expected to be the site for 200 to 300 research fires during the next 5 years. The area has been fenced and surrounded by firebreaks.

Figure F-1.--
The new prescribed fire experimental area in chaparral is equipped with a laboratory and workshop for studying the effects of environmental and physical factors on energy output of fires.

Headquarters is a 28-foot trailer-laboratory equipped for accurate weighing, determining moisture content of fuels, cooling and freezing fuel chemistry samples, and recording and studying basic environmental and physical data (fig. F-1). A workshop houses utilities and work space for analyzing physical characteristics of large fuel masses, maintaining instruments and tools, and performing related support tasks.

Phytacide modifies chemistry of shrub live oak leaves

A 2,4,5-T in oil treatment applied in January to shrub live oak consistently raised the energy of the solids (everything except water) in the leaves by about 3 percent. The change may be due to additives, chemical modifications, or both. When run through a solvent extraction process, the posttreatment leaves yielded 1.0 percent less crude fats than the pretreatment leaves. Posttreatment leaves after extraction had 2.3 percent more energy. The treatment may have changed the solubility of some chemical components, or even added some high-energy material.

Emissivity measurements guide preparations for research burns

Scaling down outdoor research fires without losing characteristics associated with large size is difficult. On our chaparral experimental area, "small" fires will be "fenced in" with highly reflective panels to feed back radiant energy and thus simulate infinite size. Because emissivity is the reciprocal of reflectivity of opaque objects, emissivity measurements were used to select a suitable material. Stainless steel, with an emissivity of 20 percent, proved superior to aluminum (weathered) with an emissivity of 50 percent.

Figure I-1.--Male spruce budworm moths caught by a sex-attractant trap. The trap consists of two unmated female moths enclosed in a vial cage in the center of a board coated with a sticky material.

Forest Insects

Spruce budworm has a strong sex attractant

Traps that attract moths have a good potential as research and survey tools. Traps are made by caging two virgin female moths in a plastic tube in the center of a 1-foot-square piece of cardboard, coated with a sticky material (fig. I-1). Male spruce bud-

worm (Choristoneura fumiferana (Clem.)) moths, attracted by an odor produced by the virgin female moths, fly upwind to the trap and get stuck in the sticky substance. As many as 223 male moths were caught on one side of the trap in a single night. Approximately 75 percent of a night's catch is caught between 8 and 11 p.m. Few are caught during daylight hours or on the windward side of the trap. These traps can help us follow the abundance of moths from year to year, and evaluate trends of infestations.

Three species of flycotchers prey on spruce budworm

Three species of flycatchers that are common inhabitants of forest areas with spruce budworm outbreaks are the western flycatcher (fig. I-2), Hammond's flycatcher, and the western wood pewee. Twenty to 25 percent of the diet of the western flycatcher was found to be spruce budworm larvae and adults. Eight to 10 percent of the diet of the other two species was spruce budworm. This information will help evaluate the impact of their predation on spruce budworm infestations.

Ponderoso pine budworm hos 1-yeor life cycle

A budworm, Choristoneura lambertiana ponderosana Obraztsov, periodically deforms or kills ponderosa pine in many parts of the central Rocky Mountains (fig. I-3). It mines the needles inside the needle sheaths. Infestations that persist may kill trees. Life history studies, needed as a basis for developing control measures, showed the budworm to have one generation per year. The first instar larvae emerge from hibernation in early June, and feed on the surface of the developing buds. After the buds open, they feed on that part of the needles within the sheath. The larvae reach the sixth instar (fig. I-4) by early July and pupate on the twigs (fig. I-5). The moths (fig. I-6) emerge in late July and lay their eggs in clusters on the pine needles. The eggs hatch in about 10 days, and the newly hatched larvae, without feeding, seek protected sites such as under bark scales. There they spin tiny silken enclosures, and become inactive until the following spring.

Figure I-3.--Top of ponderosa pine damaged by the ponderosa pine budworm.

Figure I-2.--The western flycatcher is a valuable predator of the spruce budworm. This female built her nest in a callousing wound on an aspen.

Figure I-4.--Mature larva of the ponderosa pine budworm feeds on the needles inside the needle sheath.

Figure I-5.--Larvae of the ponderosa pine budworm commonly pupate on the twigs.

Figure I-6.--Female moth of the ponderosa pine budworm ready to lay her eggs on the pine needles.

Figure I-7.--
Mature larva of a predaceous Medetera fly beneath the bark of ponderosa pine infested with the Black Hills beetle. As many as 50 have been observed per square foot of bark. These larvae are able to move beneath the bark and consume up to 10 beetle larvae each.

Predators of the
Black Hills beetle

Research on the natural control of the Black Hills beetle, Dendroctonus ponderosae Hopkins, revolved around two predaceous insects--the red-bellied clerid beetle, Enoclerus sphegeus Fabricius, and a fly, Medetera aldrichii Wheeler. There are other insect parasites and predators of the Black Hills beetle, but these are most abundant. The clerid adults feed on the beetles, each consuming up to one per day, during the emergence and attack period. The clerid larvae feed on all stages beneath the bark. As many as 15 have been found per square foot of bark. Only the larval stage of the Medetera fly is predaceous (fig. I-7). Studies are continuing on the role of these predators in the regulation of Black Hills beetle outbreaks.

Many species of nematodes
associated with
bark beetles

With each bark beetle species studied for presence of nematodes, much new and valuable information is obtained. In a study of the roundheaded pine beetle, Dentroctonus adjunctus (Hopkins), two new species of internal parasites were found. In addition, 25 other species were found in the galleries of this bark beetle, of which 9 were new species.

Nematodes were known to be parasites of bark beetles nearly 75 years ago, but only recently have we learned something about their great abundance and effect on bark beetles. The adult nematodes are tiny white worms 1/2 mm. to 7 mm. in length. There may be from one to many in one bark beetle. Bark beetle galleries may teem with nematodes. Their full effect upon the population dynamics of tree-killing bark beetles is not yet known. We know that the internal parasites weaken their hosts, resulting in shorter egg galleries and few eggs being laid. One species kills its hosts. Much basic research on the ecology and epidemiology of these parasites is essential before their use as biological control agents can be forecast.

Forest Diseases

Cull due to red rot is high
in ponderosa pines on
Navajo Indian Reservation

Fifteen percent of the gross volume of virgin ponderosa pines on the Navajo Indian Reservation were found to be affected by red rot caused by the fungus Polyporus anceps. A light improvement-selection harvest cutting removed 48 percent of the gross volume (41 percent of the net) and 67 percent of the red rot volume (a cull percent of 21), leaving a residual stand with 8.5 percent of the gross volume already lost because of red rot.

The red rot cull of 8.5 percent in the residual stand will increase by an estimated 0.5 percent each decade. Any change in cutting policy leading to the removal of a different proportion of red rot than was removed in the study would have a corresponding effect on the cull percent in the residual stand and in the second cut. For example, cutting all yellow pines (except low-risk trees) would remove 78 percent of the red rot volume and 56 percent of the gross volume. Red rot cull in the residual stand would then amount to 7 percent immediately after cutting, or 8.5 percent at the end of a 25-year cutting cycle.

Although red rot was found to be closely related to several factors studied, tree age was by far the most significant. Bark color in the lower trunk, however, was a better field criterion of red rot cull than broad age classes, whether actual or estimated.

Dothistromo needle blight of pines controlled by properly timed fungicide opplicotions

Needle blight caused by Dothistroma pini Hulbary causes extensive damage to Austrian and ponderosa pines in the Central and Southern Great Plains. Spores of this fungus were trapped only during periods when rain fell. Initial infection in eastern Nebraska occurred June 16-23 in 1964, and May 20-27 in 1965. Symptoms were not evident until 4 months after initial infection. Excellent control was obtained with two applications of Bordeaux mixture when first application was made by mid-May (for protection of old foliage), and the second by mid-June (for protection of new foliage).

Field studies expond knowledge of hosts ond distribution of dworfmistletoes

Continuing field studies on the hosts and distribution of the dwarfmistletoes (Arceuthobium spp.) have revealed several previously unreported host-parasite combinations and new locations (table D-1).

Although mountain hemlock is quite susceptible to the larch dwarfmistletoe, western hemlock appears to be immune to it. On the other hand, both hemlocks are attacked by the hemlock dwarfmistletoe in the Pacific Coast States.

In greenhouse inoculation tests at Fort Collins, Colorado, eastern white pine was found to be very susceptible to the limber pine dwarfmistletoe (A. campylopodum f. cyanocarpum).

These and many other records of new hosts and geographic distribution are being used in a taxonomic revision of the genus Arceuthobium.

Externol indicotors con be used to estimote decoy of Engelmonn spruce in Colorodo

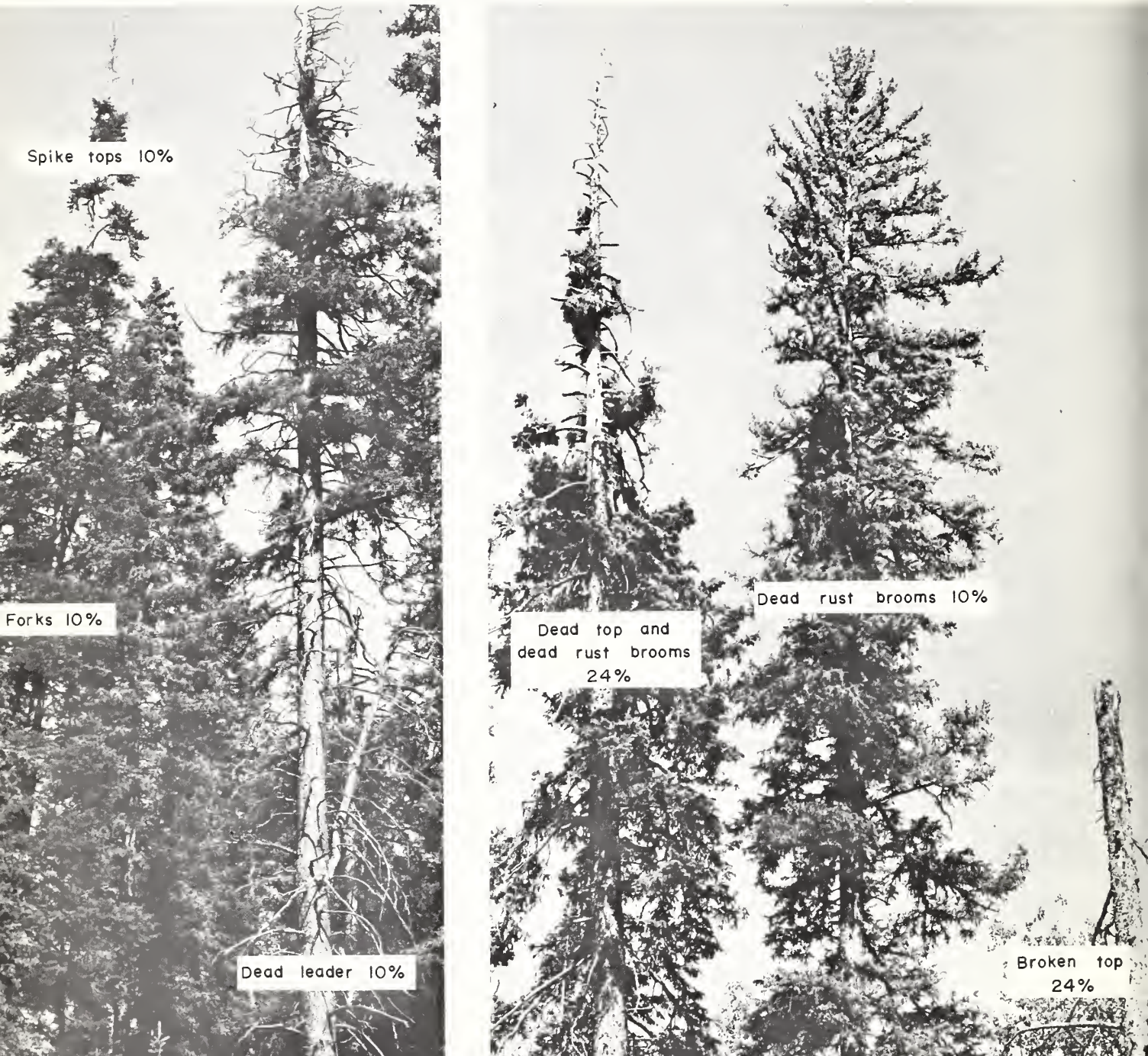
Average deductions for 11 cull indicators were determined from over 2,000 abnormalities on 1,027 merchantable Engelmann spruce trees from throughout Colorado. On a board-foot basis, trees with Fomes pini punk knots or sporophores suffered an 81 percent loss. Cull in trees with broken or dead tops with adjacent dead rust brooms averaged 24 percent. Trees with basal wounds, dead rust brooms, dead leaders, frost cracks, forks, spike tops, trunk wounds, or double trunks joined at the base had average deductions of 10 percent (fig. D-1).

Two-thirds of the butt rot encountered was associated with one or more of the indicators listed above. The principal butt rot fungi were Fomes nigrolimitatus, Pholiota alnicola, Polyporus tomentosus var. circinatus, Corticium radiosum, Coniophora puteana, and Fomes pinicola. More than 90 percent of the trunk rots were associated with the cull indicators. Fomes pini was the most important, and usually caused the greatest amount of cull. Other important trunk rot fungi were Stereum sanguinolentum, S. sulcatum, S. abietinum, and Lenzites saepiaria.

Table D-1. --Host-parasite combinations and locations previously unreported

Common name	Scientific name	Tree host	Location
Dwarfmistletoes:	Arceuthobium:		
Pinyon	campylopodum f. divaricatum	Mexican pinyon[1]	West Texas
Sugar pine	campylopodum f. blumeri	Western white pine[1]	Oregon[2]
Larch	campylopodum f. laricis	Mountain hemlock[1]	Idaho, Montana
White fir	campylopodum f. abietinum	White fir	Utah[2]
Douglas-fir	douglasii	Douglas-fir	Nevada,[2] Wyoming[2]
Southwestern	vaginatum subsp. cryptopodum	Bristlecone pine[1]	Colorado
Lodgepole pine	americanum	Bristlecone pine[1]	Colorado

[1] First report on this host. [2] First report from this State.

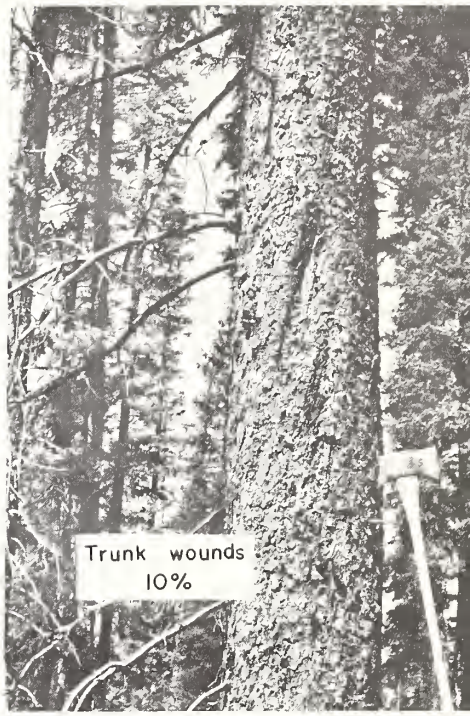


Crown indicators of cull

Figure D-1.--Deduction percentages for 11 cull indicators found on Engelmann spruce trees in Colorado.

Fomes pini punk knots or sporophores 81%

Frost cracks 10%



Trunk wounds 10%

Joined base 10%

Basal wounds 10%

Basal indicators of cull

Nematodes damage mycarrhizae

Nematodes that feed on fungi were found to be widespread in the forest soils of central New Mexico. One of them, an undescribed species, greatly reduced the growth of two fungi in pure culture during laboratory tests. One fungus was a mycorrhiza former; the other, a pseudomycorrhiza former. The nematode reproduced readily on cultures of both fungi, but died without the fungus to feed on. Such nematodes may be important in causing a deficiency of mycorrhizal fungi on low-elevation conifers in New Mexico, which in turn might impair drought resistance of the trees.

Germination of some tree and shrub seeds improved by peroxide treatment

Highest germination, rapid germination, and contamination-free seedlings are necessary for mycorrhizal synthesis trials and other laboratory and greenhouse tests. Soaking or washing seeds of ponderosa and pinyon pines, one-seed juniper, mountainmahogany, and cliffrose in water for 48 hours, followed by a half-hour soak in 30 percent hydrogen peroxide, increased the germination. The same treatment applied to fourwing saltbush seeds, however, retarded germination. Besides improving germination, the peroxide treatment, with the one exception, also effectively controlled seedborne microflora.

Recleaning dwarfmistletoe from ponderoso pine stand more expensive than original cleaning

Silvicultural "cleaning" of dwarfmistletoe from ponderosa pines on about 9,000 acres of the Mescalero Apache Indian Reservation in 1952-55 reduced visible infections to less than 1 percent of residual trees. "Cleaning" consisted of felling infected trees or pruning infected branches.

Development of latent and missed infections required recleaning 8 to 9 years after the original cleaning. The recleaning again reduced visible infection to less than 1 percent. Cost of recleaning was $7.09 per acre as compared with $5.26 for the original operation. The higher cost was due to (1) more time spent in searching for infections, (2) trees treated were generally larger and more of the workers' time was allocated to sawyers (sawyers' time was more expensive than axmen's), and (3) labor cost increased substantially between operations--the average hourly wage for axmen was up $0.72, sawyers $0.85, and foreman $0.68.

Antibiotics do not control western gall rust or aspen cankers

Two antibiotics, cycloheximide (Actidione) and Phytoactin, were applied as basal sprays to 479 western gall rust cankers caused by Peridermium harknessii on lodgepole and ponderosa pines, and to 129 aspen cankers caused by Ceratocystis fimbriata, Cytospora chrysosperma, Hypoxylon pruinatum, and Cenangium singulare.

Two and 5 years after application, cycloheximide and its acetate, methylhydrazone, oxime, and semicarbazone derivatives, and Phytoactin in No. 1 fuel oil had depressed sporulation of western gall rust in the spray zone temporarily, but gave no lasting control. Similar results were obtained in the treatment of aspen cankers--temporary inhibition of fruiting, but continuation of canker activity and eventual girdling of the trees (fig. D-2).

Host range of Hypoderma mexiconum extended

Several new hosts were determined for Hypoderma mexicanum Wolf on the basis of recent collections from Mexico. This needlecast disease is capable of widespread injury to Pinus cooperi, P. durangensis, and P. engelmannii. P. teocote is probably also attacked. A comparison of specimens on these hosts with the type collection on P. leiophylla justifies a change in the original description to indicate a subepidermal position. An atypical imperfect state with two-celled spores was occasionally present in addition to the typical imperfect state. The fungus appears more closely related to H. lethale Dearn. than to H. saccatum Darker.

Figure D-2.--Cankers after antibiotic treatment:

Active Hypoxylon canker enlarged from 1/2 to 2/3 of trunk circumference in 3 years.

Ceratocystis canker developed black exudate along its edge.

Range Management and Wildlife Habitat Research

Range Management

Native perennial grasses and burroweed don't use soil moisture heavily at the same time

At the Santa Rita Experimental Range in southern Arizona, the undesirable burroweed used soil moisture rapidly in early spring and again late in summer. In contrast, perennial grasses used moisture most rapidly during the first few weeks of the summer rainy season, and were relatively inactive in the spring. Moisture use in summer by warm-season annual grasses was similar to that of the perennial grasses. Another difference was that moisture near the surface was more readily used by the perennial grasses, while burroweed was more active at greater depth. This was expressed most strongly during the spring period by much more rapid soil moisture depletion by burroweed at 12 inches and in summer by more rapid use of soil moisture by grass at 3 inches. These differences in season and depth of soil moisture use explain why burroweed control does not greatly increase perennial grass cover or yield.

Burning controls burroweed temporarily but does not increase grass production

Although burning resulted in an immediate reduction in burroweed, the burroweed again became reestablished in a test of controlled burning on semidesert vegetation on the Santa Rita Experimental Range. A controlled burn in 1952 killed 98 percent of the burroweed (fig. R-1). Following the burn, yields of annual grasses were higher on the burned areas than on unburned range in wet years, as long as burroweed density remained low. Perennial grasses recovered in about 2 years from the initial detrimental effects of fire, but production and cover did not increase as the result of burning. Burroweed numbers increased greatly in the wet winters of 1956-57 and 1957-58. By 1965, burroweed density had increased to 7,175 plants per acre compared to 3,762 before the burn. Perennial grass cover and yield in 1965, 13 years after the fire, were lower on the burned area than on the adjacent unburned range.

Figure R-1.--Changes in burroweed density on the same area near Tucson, Arizona:

June 1952
(immediately before burning)
4,442 burroweed per acre

Figure R-2.--A widespread stand of snakeweed reduced production of summer-growing grasses.

Snokeweed reduces growth of blue gromo

Production of blue grama in a blue grama-broom snakeweed-actinea community was increased 14 to 30 percent when the half shrubs were reduced by spraying with selective phenoxy sprays. Snakeweed is the second most abundant nonforage species on Southwestern pinyon-juniper ranges. It is exceeded only by the junipers (fig. R-2). Although blue grama, a summer-growing grass, was reduced by the presence of the half shrubs, bottlebrush squirreltail, a spring-growing grass, was not.

Microscope-point method determines species composition of steer diet

A microscope-point sampling technique, developed in cooperation with the University of Arizona, accurately determined relative amounts of major forage species in the diet of rumen-fistulated steers. Keys were prepared for identifying fragments of several important semidesert grasses and associated palatable shrubs. The method, though time consuming and requiring careful, well-trained observers, gave more accurate estimates of the species composition of the animal diet than estimates obtained by watching the animal graze. Data obtained by the method showed that the grazing steer was very selective. The species composition of material in the rumen changed seasonally in response to changes in the animal's preference, and usually showed little resemblance to the relative abundance of available forage species (fig. R-3).

Predictoble correlotion exists among moisture contents of ronge plonts

A strong correlation has been found among moisture contents of mountain grassland plants during summer months. On the basis of those relationships, and the measured moisture content of one or more representative species, one can predict with reasonable confidence the moisture content of associated

September 1958
261 burroweed per acre

April 1966
10,340 burroweed per acre

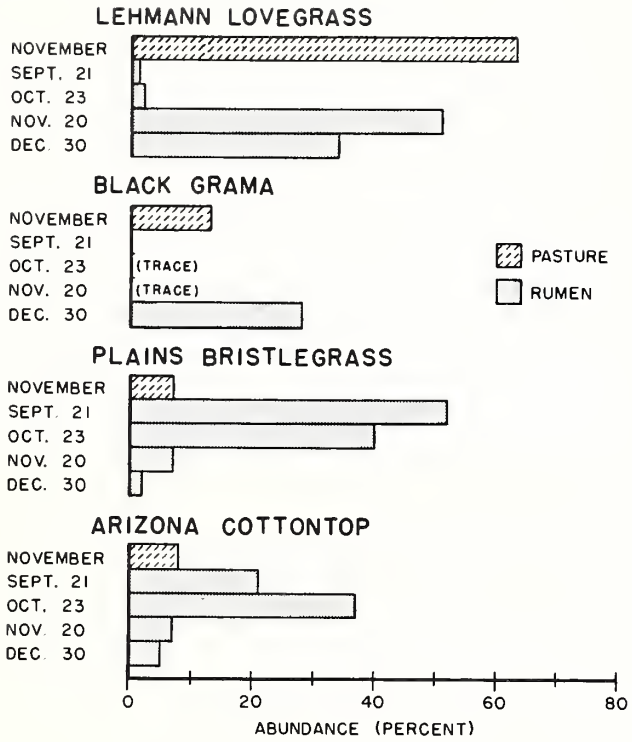


Figure R-3.--Relative abundance of major perennial grasses in study pasture in November and in rumen samples at monthly intervals.

species. Available evidence indicates that herbage moisture relations are relatively stable and, once determined, can be used for prediction purposes year after year.

On Black Mesa in western Colorado, moisture relationships were determined for three grasses, seven forbs, and one shrub from herbage samples collected from 1957 to 1960. Numerous additional samples collected during the next 4 years were used to test the reliability of those relationships. Four-fifths of the values predicted from those of Idaho fescue were within 5 percent, and nearly all were within 7 percent, of observed values. Predictions based on aspen fleabane were equally as reliable.

Species for which moisture content could be predicted were Thurber fescue, Letterman needlegrass, western yarrow, hairy goldaster, Fremont geranium, aspen peavine, common dandelion, agoseris, and Parry rabbitbrush.

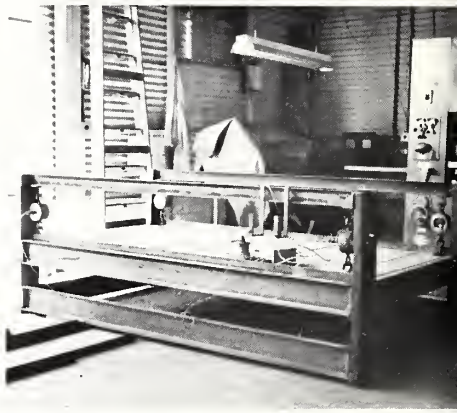
Although its limitations are not fully known, the prediction method apparently offers a potentially valuable and efficient means for estimating moisture content of rangeland herbage.

Experimental scale weighs range cattle without disturbing them

A scale that weighs experimental cattle automatically as they go to water was developed in cooperation with the University of Arizona and tested on the Santa Rita Experimental Range. The scale essentially is a platform supported at the corners by strain-gage transducers (fig. R-4). Changes in electrical resistance, as an animal crosses the platform, are recorded as oscillograph traces on a recorder (fig. R-5). The traces are converted to animal weights. Since cattle crossing the scale do not shrink due to handling, they can be weighed frequently to determine how changes in animal weights are related to changes in vegetation, weather, and related factors.

Figure R-4.--Experimental model of the automatic scale:

Under construction.



In place, at entrance to water.

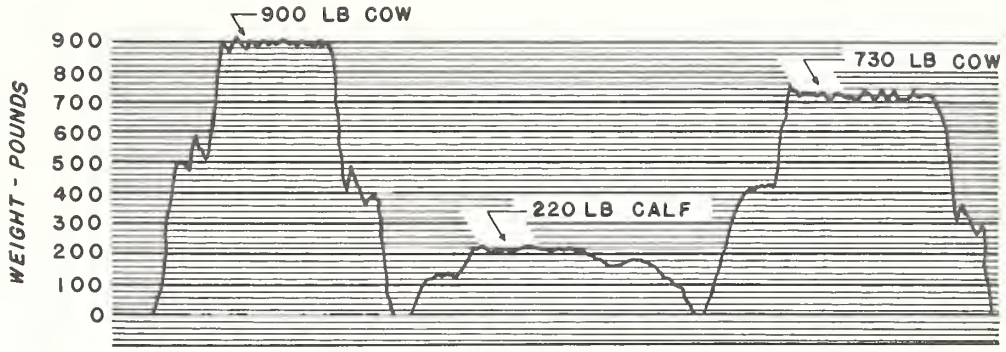


Figure R-5.--Oscillograph trace made by three different animals as they crossed the scale to water.

Juniper trees killed by 60-percent scorch

To get satisfactory kill when burning individual trees of nonsprouting junipers (oneseed and Utah juniper), 60 percent or more of the tree should be scorched (fig. R-6). Underburning does not kill the trees, while overburning unnecessarily increases treatment cost (fig. R-7). These results have been obtained from tests of individual tree burning as a method of juniper control in northern Arizona.

Juniper trees reduce the forage production of millions of acres of western rangelands. Because of this, many ranchers and land management agencies have been conducting juniper control programs, including burning individual trees.

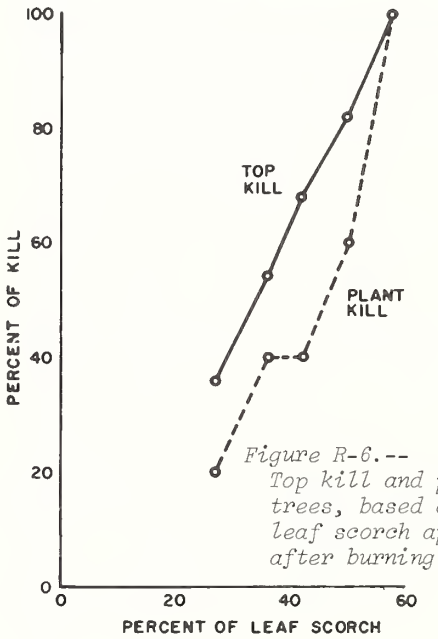


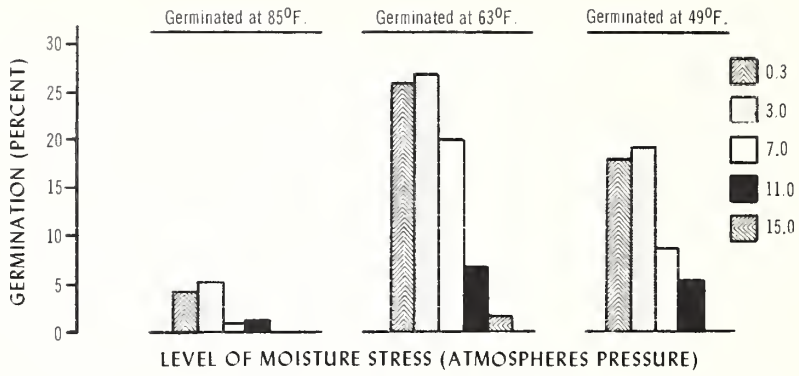
Figure R-6.--Top kill and plant kill of trees, based on percent of leaf scorch apparent just after burning.

Figure R-7.--Burning procedure should be to get sufficient crown scorch in optimum time:

Ideally, about two-thirds of the crown should be scorched.

Improperly, excessive time was spent on tree in foreground; not enough crown was scorched to kill tree in background.

Figure R-8.--
Average germination of six sources of fourwing saltbush seeds under different levels of moisture stress.



Germination of fourwing saltbush influenced by moisture stress

Germination of fourwing saltbush seeds decreased as moisture stress increased, regardless of temperature (fig. R-8). Seed from six sources in Arizona and New Mexico were tested for 28 days under moisture stresses of 0.3, 3, 7, 11, and 15 atmospheres (atm.) of osmotic pressure at temperatures of 85°, 63°, and 49° F. Average germination was significantly greater under the 0.3- and 3-atm. levels than under the other levels. Nevertheless, seeds germinated fairly well even under the relatively high 7-atm. level when the temperature was 63° F.; this suggests that moisture stress may be less important in seed germination when the temperature is near optimum. Seeds from one source germinated better than the others under the 11- and 15-atm. levels, which indicates it might germinate more readily under arid conditions.

Seeded ranges extend quality forage period

Heavier, uniform calves, like those at the Manitou Experimental Range in central Colorado (fig. R-9), are the benefits of incorporating seeded ranges into a grazing management system with native ranges. Over the past 3 years, calves weaned from this system averaged 32 pounds heavier and brought $7.70 more per head than calves raised on native range.

Chemical and botanical analyses of forage samples collected from freely grazing ruminal fistulated steers (fig. R-10) indicated seeded ranges increased the time range cows were on a better quality diet. According to standards of nutrition set by the National Research Council, crude protein in the diet of the herd grazing both native and seeded ranges on an integrated basis was adequate to excessive for 10 months out of the year, whereas crude protein in the diet of the herd grazing native ranges only was adequate for only 8 months. The seeded ranges provided a 2-month advantage of adequate dietary protein because they started growth earlier in the spring, and became dormant later in the fall. Phosphorus in the diet followed a similar trend. Seasonal trends in both crude protein and phosphorus indicated that the stage of forage maturity at time of consumption was of major importance in determining the general nutritive quality of the diets of both herds.

Figure R-9.--
When seeded ranges are grazed in early spring and late fall on a year-long management system, uniform calves of good quality are a primary benefit.

Figure R-10.--Ingested forage taken from the rumen provides an estimate of the plant species consumed. The value of this forage for animal nutrition can then be determined by chemical analysis.

Crested wheatgross is gaad sheep farage

In cooperative studies with the University of Wyoming, crested wheatgrass was found to be highly digestible for sheep forage. Average cellulose digestibility as determined from artificial rumen procedures was 64 percent.

Crested wheatgrass was sampled by clipping, plucking, and esophageal fistula on June 9, July 11, July 28, and August 24. Artificial rumen cellulose digestion was significantly greater on June 9 than on subsequent dates. Crested wheatgrass sampled on July 28 had significantly lower cellulose digestibility than all other samples. Cellulose digestion was essentially the same for samples collected by all three methods except on the July 28 date, when plucked samples had significantly higher cellulose digestibility than esophageal or clipped samples (fig. R-11).

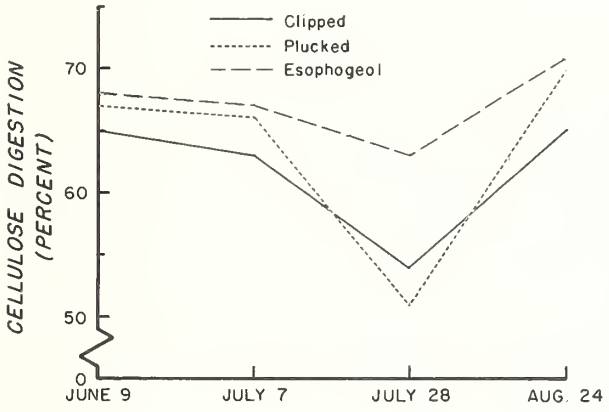


Figure R-11.--
In vitro digestibility of crested wheatgrass sampled on four dates, Laramie, Wyoming.

Ratotion grazing did nat campensote for heavy stocking

Relatively heavy stocking of range grazed in rotation substantially reduced production of Idaho fescue, the key forage species, over a 6-year period; under moderate stocking, production of fescue responded the same to rotation and season-long grazing (fig. R-12). These results were obtained on soil derived from sedimentary rocks in the Big Horn Mountains

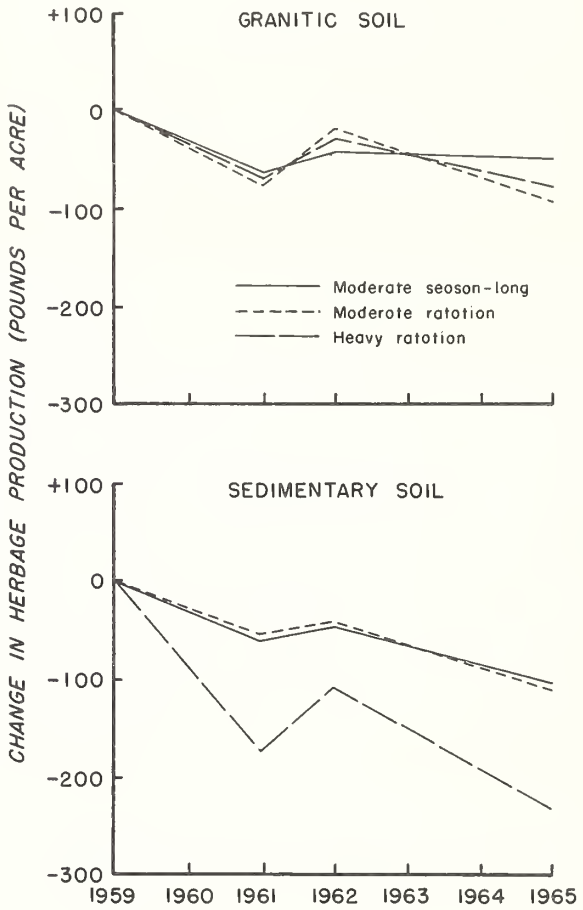


Figure R-12.--
Changes in Idaho fescue production on two soils and under three systems of grazing, Big Horn Mountains, Wyoming, 1959-65.

of Wyoming. No differences were observed on granitic soils.

As a basis for comparison, one range unit was grazed summer-long by steers at a rate aimed to utilize 40-45 percent of Idaho fescue. An adjacent range, stocked at the same rate, contained three subunits in which grazing was rotated. A third range, stocked 1-1/2 times as heavily, also was subdivided into three subunits in which grazing was rotated. Soils from the two types of parent rock were present on each range.

Steers made highest daily weight gains in the rotated unit grazed moderately, and lowest in the heavy rotation unit. Gains were difficult to relate to system of management, however, because of the initial differences in forage production among the three ranges. When evidence was evaluated in terms of factors known to influence daily gain, it was concluded that, at moderate rates, season-long and rotation grazing were equally efficient, but the relatively heavy stocking rate resulted in lower weight gains.

Wildlife Habitat

Phosphorus deficiency suspect in the chaparral habitat of Arizona

Because of inadequacy of other forage, crown sprouts of some species of Arizona chaparral (fig. WH-1) are used heavily by deer from May through July, and again in the fall. During periods of heaviest use (June-July, September-October) crude protein content of the crown sprouts is above 12 percent, and calcium content is above 0.75 percent. Phosphorus content, however, is only 0.10 to 0.15 percent during most of the primary use period. Judging from the nutritional requirements of the eastern white-tail deer, the crude protein content of the crown sprouts is closer to optimum than survival nutritional level, calcium content is above optimum, and phosphorus content is below survival level. Unless phosphorus is supplemented from some other food source, it is probably deficient in the diet of deer.

Figure WH-1.--Crown sprouts of burned Arizona chaparral furnish valuable forage for deer during a time when other food materials are deficient.

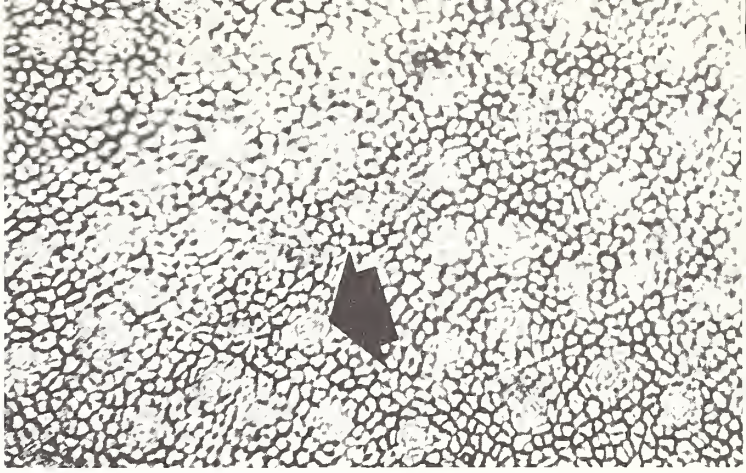


Figure WH-2.--Characteristic and specifically identifying stomatal pattern on the epidermis of jojoba (× 100).

Qualitative identification of forage remnants in deer feces

Identification of forage items in fecal material offers an alternative or supplementary approach to food-habits studies of big-game animals, which in the past have depended largely upon analysis of stomach content and direct observation of feeding activity.

To evaluate the fecal-material technique, captive deer were fed single forage species. Subsequently, droppings containing forage remnants were collected, examined, and photographed through a microscope (fig. WH-2). So far, 17 species, including grasses, shrubs, trees, and forbs, have been fed and morphologically identified in deer feces. Quantitative means of assaying these fecal items is under study so that the technique can be extended to food-habits analysis under field conditions.

Wet meadows are important wildlife habitat

Wet meadows within forest habitats of spruce-fir and ponderosa pine are important to big game of the Southwest, particularly deer and elk. These wet meadows (fig. WH-3)

Figure WH-3.--Wet meadows, interspersed throughout forest lands of the Southwest, furnish large amounts of highly nutritious forage per unit area for big game.

contain sedges, rushes, and grasses that produce large amounts of nutritious forage. They are surrounded by a slightly higher and drier zone, mostly of perennial grasses, here identified as dry meadow. Surrounding the meadows on drier sites are forests of ponderosa pine, fir, or spruce that overstory perennial grasses and forbs. Total herbage production and the crude protein content of representative forage species from the three sites were strikingly different. Averages for 1965 were:

	Herbage production (Lbs./acre)	Crude protein (Pct.)
Forest understory:	215	
Prairie Junegrass		2
Arizona fescue		3
Dry meadow site:	1,245	
Pine dropseed		4
Mountain muhly		4
Wet meadow site:	1,875	
Rushes		6
Sedges		9

Tree and shrub abundance affect deer and elk use of pinyon-juniper habitat

In the Southwest, where pinyon and juniper trees, shrubs, and grassland grow in a mosaic and sometimes storied association, deer prefer a denser growth of trees and shrubs than do elk. In general, however, deer and elk use is associated with abundance of shrubs. Analyses of rumen content in the fall show shrubs to be the preferred dietary item. Moreover, species preference for shrubs is almost proportionate to density of shrubs (fig. WH-4). Trees are, however, an important factor in overall habitat use. Elk and deer use small patches of trees, whether shrubs are present or not (fig. WH-5).

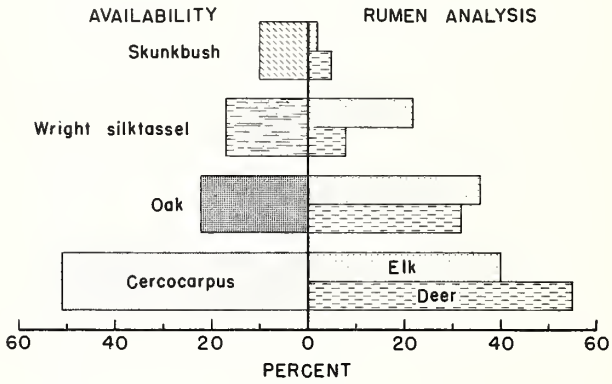


Figure WH-4.--Density of shrubs is related to their occurrence in rumen contents (fall season) of deer and elk.

Use of the sagebrush type by deer in winter

Deer used the big sagebrush type heavily during a winter of exceptionally deep snow. In

Figure WH-5.--A pinyon-juniper woodland habitat on the Gila National Forest in southern New Mexico. Abundance and arrangement of the different life-forms affect deer and elk use.

Figure WH-6.--Deer concentrated on sagebrush range during a severe winter when ranges at higher elevation, with a greater variety of browse plants, had a deep snow cover.

the winter of 1964-65, in Middle Park, Colorado, where snows were deep, deer were restricted to the sagebrush type through much of the winter (fig. WH-6). Heavy starvation losses resulted. In contrast, 1965-66 was a relatively open winter, and most deer remained higher where snow was 1 to 1.5 feet deep but there was a greater variety of food and cover--aspen and conifers, mixed shrubs, and sagebrush. Under these conditions, the percentage of sagebrush plants browsed was much lower than the corresponding percentage for bitterbrush, rubber rabbitbrush, Greenes rabbitbrush, serviceberry, and aspen. The total use of sagebrush, however, probably equaled or exceeded that of any one of those less abundant species. There were virtually no starvation losses in the winter of 1965-66 when this variety of vegetation was available.

General snow depths on the winter range did not restrict deer movements, but drifts up to 6 feet deep along the east edges of north-south ridges precluded use of some of the best browse stands. Such drifts not only protect browse plants in winter, but promote better moisture conditions for growth in summer.

Minimum acreage of forest habitat for deer and elk determined

Use of spruce-fir forest cover patches in grassland areas of the Southwest by deer and elk varies with their acreage. Often, 1- to 50-acre patches of forest are interspersed in the grasslands (fig. WH-7). Deer use cover patches down to about 1 acre. Use increases

Figure WH-7.--Extensive areas of grassland in spruce-fir forests of Arizona and New Mexico often contain small patches of forest, which are utilized by elk and deer.

with size to about 20 acres, then decreases as patches become larger (fig. WH-8). No deer use was found beyond 450 feet from the forest edge. Cover patches were about 10 acres before they were used much by elk. In larger patches, elk use increased proportionate to area, up to at least 70 acres. Elk use was not affected by distance from forest edge.

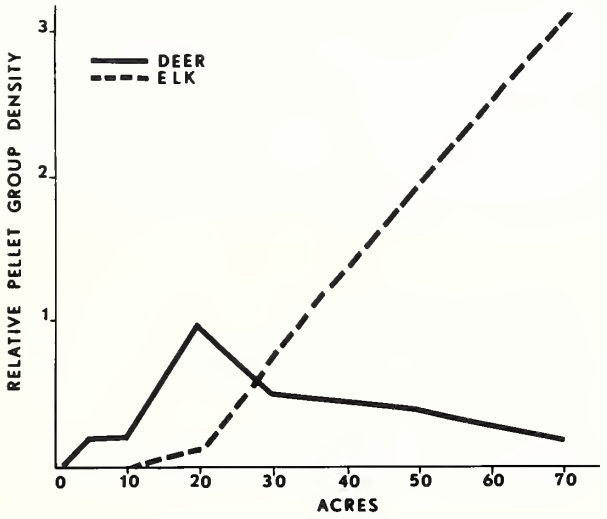


Figure WH-8.--Use of forest cover patches by deer and elk varies with acreage.

Age of tree groups in ponderoso pine forests affects use by deer

Ponderosa pine of the Southwest grows typically in age groups from 0.1 to several acres in size. Deer prefer mature age groups to immature age groups, presumably because of the greater abundance of understory forage. For example, under mature age groups, with above 40 square feet of basal area per acre, abundance of pellet groups is closely related to production of understory vegetation (fig. WH-9). In immature tree age groups, there are disproportionately higher numbers of pellet groups above 160 square feet of basal area, because deer use these areas as bedding sites.

Figure WH-9.--
For mature age-groups of ponderosa pine, production of understory vegetation decreases gradually as overstory basal area increases. Above 40 square feet of basal area per acre, abundance of deer pellet groups is closely related to production of understory vegetation.

Deer hove decided preference for certoin Block Hills ronge

In the Black Hills of South Dakota, deer show a decided preference for open stands of ponderosa pine on old burns (fig. WH-10). During the period 1960-65, the open stands with an understory largely of Kentucky bluegrass and forbs received 35 times as much use as the dense pole stands. On the basis of 13 pellet groups per deer-day use, this would amount to 55 deer days in the open stands compared to only 1.6 deer days in the dense pole areas. Dense pole stands of ponderosa pine have only sparse understory vegetation. These and other sites in the Black Hills are being investigated cooperatively with the South Dakota Department of Game, Fish, and Parks to determine the combinations of vegetation, soil, and physical environment that provide the best deer habitat.

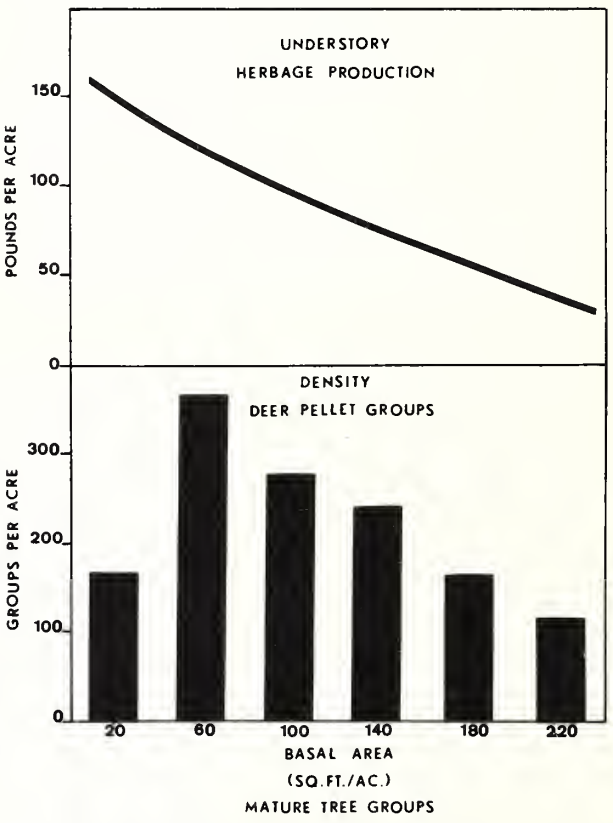


Figure WH-10.--Deer show decided preference for certain Black Hills range types:

This open stand of ponderosa pine on an old burn has an understory of Kentucky bluegrass and forbs, and supports one of the heaviest white-tailed deer concentrations in the Black Hills.

Forest ranges with dense stands of ponderosa pine characteristically produce small amounts of forage and support low deer populations.

Stock ponds important for waterfowl on National Grasslands

Observations on 33 stock ponds on the Buffalo Gap and Fort Pierre National Grasslands showed at least 25 species of waterfowl and shore birds used these impoundments. A total of 926 adult waterfowl were observed on 87 visits to these ponds between June 23, 1964, and May 31, 1966. Seven species of dabbling ducks, 3 species of diving ducks, and 15 species of shore birds were recorded. Although the stock ponds are used primarily as resting areas during waterfowl migration (fig. WH-11),

Figure WH-11.--Dabbling ducks, such as this mallard drake, use prairie stock ponds for resting during migration, and frequently nest in adjacent areas.

a large number of nesting ducks were observed. Ponds on the National Grasslands of the Great Plains offer considerable potential for waterfowl production, and their importance will increase as other wetlands are lost by drainage projects. Because of this importance, a study to determine the value of fencing to improve wildlife habitat around stock ponds is being undertaken (fig. WH-12).

Figure WH-12.--Stock ponds on the National Grasslands of South Dakota:

Unfenced; shoreline vegetation is depleted by grazing.

Fenced; shoreline vegetation is valuable as wildlife habitat.

Forest Biology

(In cooperation with the Fish and Wildlife Service, U. S. Department of the Interior)

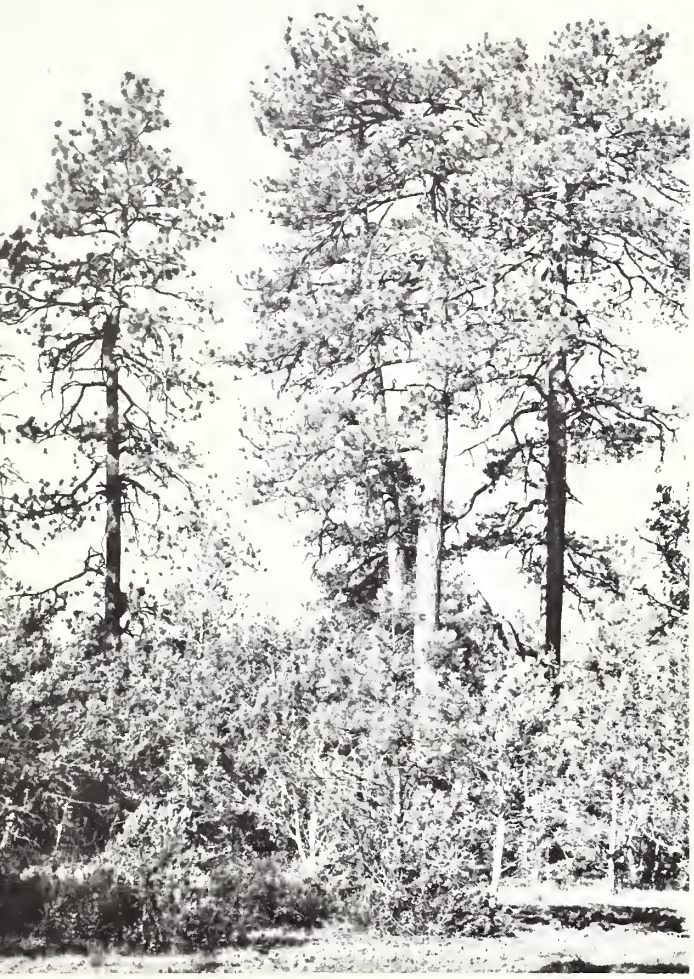


Figure B-1.--
A small group of mature ponderosa pine, overstorying pinyon-juniper, which has been used consistently by Merriam's turkeys for roosting.

Turkey roost trees characterized

Early findings suggest that Merriam's turkeys prefer mature ponderosa pine trees for roosting (fig. B-1). Of 32 roost trees classified as to characteristics on the Apache Indian Reservation, the majority were located on easterly or northeasterly exposures near the top of a ridge. In all cases the trees were limbless for at least 20 feet from the ground; limbs were relatively bare and wide spreading. These findings suggest that preservation of mature ponderosa pine trees on similar sites in logging areas may help maintain turkey habitat.

Merriam's turkeys use a variety of foods

Analysis of crop contents from 32 Merriam's turkeys collected on the Fort Apache Indian Reservation from November 1964, through April 1966, suggests that turkeys utilize a great diversity of foods. The turkeys are highly adaptable, and vary the food selected with available seasonal food supplies (fig. B-2).

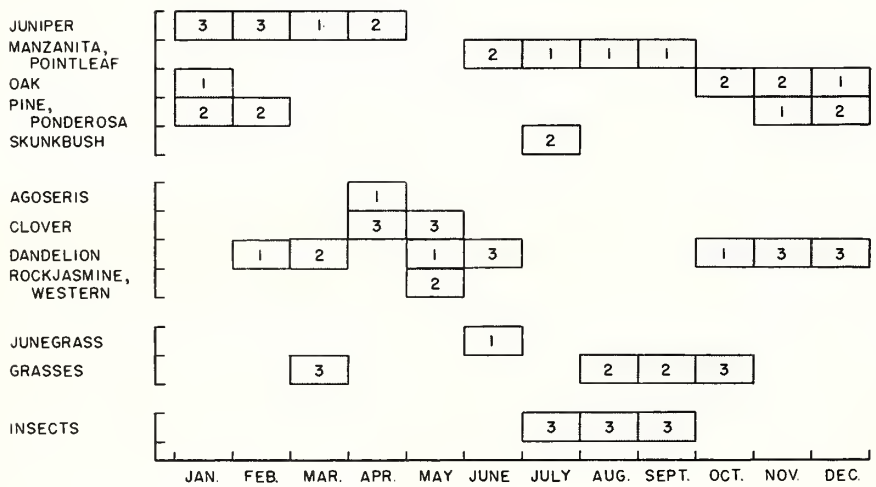


Figure B-2.--
Monthly variation in the three major food items in crops of Merriam's turkeys collected on the Fort Apache Indian Reservation, Arizona, November 1964 to April 1966.

Acorns and ponderosa pine seeds comprised the major portion of the fall and early winter diet; in late winter, juniper berries were important. Succulent forbs and grasses replaced the seed diet in spring and summer. As insects became available in summer, they were taken in large quantities. Manzanita berries, when available, were eagerly taken in July, August, and September. Both agoseris and common dandelion were taken in considerable quantity when available.

Grazing intensity did not influence pocket gopher numbers

The mean fall population of northern pocket gophers was sampled over a 10-year period on grazed Thurber fescue-forb range, Black Mesa Experimental Forest and Range, western Colorado. Although average populations varied from 32 animals per acre in 1958 to 1 in 1961, they were similar in any one year on ranges grazed at light, moderate, and heavy intensities by cattle from mid-July to October 1 (fig. B-3). Heavy grazing, sometimes believed to contribute to range habitat conditions favoring pocket gophers, thus did not result in larger populations than found on moderately or lightly grazed range.

Northern pocket gopher population drops second time in 10 years

The population of northern pocket gophers on grazed range dropped sharply to 8 animals per acre in 1966 on Grand Mesa, western Colorado, after having increased to 21 per acre in 1965. This is the second decline in population since 1956. The previous severe low was in 1958.

The 1958 low was attributed, largely, to low production of young; almost no young-of-the-year animals occurred in the fall population. The small population in 1966 could not be attributed to low production of young, however, for 73 percent of the fall population was composed of young animals. The low population was attributed, in part, to poor overwinter survival of animals, for the spring breeding population in 1966 was very low.

Figure B-3.--
Populations of mountain pocket gophers were estimated annually on sample plots by:

Live-trapping animals.

Counting mounds.

Counting earth plugs.

Deer mice most common rodents on salt-desert shrub type

Deer mice were the most common rodents captured in a small mammal inventory, conducted annually over a 10-year period (1957-66) on watersheds in the salt-desert shrub type, Badger Wash Experimental Area, west-central Colorado. The mean population varied from 0.7 to 6.2 deer mice per acre in the annual mid-May sampling. The smallest population occurred in 1961, the largest in 1966. Populations were usually below four animals per acre in the 10-year period.

Other rodents captured in the inventories were desert harvest, piñon, grasshopper, and Apache pocket mice, Ord kangaroo rats, desert packrats, and white-tailed antelope squirrels. Not all of these species were caught every year, however, and, when caught, were taken in exceedingly small numbers.

The rodent populations were sampled on eight watersheds as part of a cooperative study in which vegetation, runoff, sediment production, intensity of storm, and other hydrologic factors are being evaluated. Four watersheds are protected from livestock grazing and four are grazed in winter by cattle and sheep. No differences in rodent populations were found between the grazing treatments.

Montane vales papulation law on Black Mesa ranges

After peaking at a population of about six animals per acre in 1965, the montane vole population on grazed range, Black Mesa Experimental Forest and Range, Colorado, dropped to about four animals per acre in 1966. The 1965 population was the largest recorded in 10 years of sampling. Population estimates were based on live-trapping and snap-trapping inventories conducted annually in mid-July.

Populations of voles are being determined on ranges grazed at light, moderate, and heavy intensities of use by cattle in summer and early fall. Voles are considered competitive with cattle, particularly in periods of abundance, for range vegetation (fig. B-4). The low numbers found would be expected to have minimal effect on the vegetation.

Figure B-4.--Montane voles leave a ring of clipped stems around Thurber fescue plant as a result of their activity beneath the snowpack in winter.

Forest Economics, Utilization, Marketing, and Recreation Research

Forest Economics

Systems developed for multiple use ond economic evoluotions

Parametric linear programming is one of the new analytical and data processing techniques being used on the Beaver Creek Pilot Watershed Evaluation Project in northern Arizona. This technique makes possible manipulation and comparison of a great many different combinations of large quantities of complex data. After further testing and development, it may be used by natural resource managers in the complex job of planning and carrying out effective multiple use management.

Data needed for multiple use and economic evaluations of proposed watershed management programs include:

- Kinds and amounts of natural resources available.
- Money and manpower available.
- Costs of proposed management and treatments.
- Effects of proposed treatments or management on the various multiple uses and products.
- Values of the several products and uses.
- Alternative management policies and objectives.

The work at Beaver Creek has been designed to develop these kinds of data through a series of pilot tests on controlled watersheds. Development and pilot testing analytical systems is an important part of the job, too. Although partial analyses of resource management problems have been made through the years, and some researchers have made recent progress on analytical methods, no satisfactory comprehensive method exists for multiple use economic evaluation of natural resource management alternatives.

Alligator juniper watershed treated

One of 18 small watersheds in the Beaver Creek Pilot Watershed area was clearcut during the late summer of 1965. The treatment, designed to yield a maximum amount of surface water, is thus a "benchmark" treatment that will establish an upper limit to opportunities for increasing water yield from similar watersheds.

All trees, mostly alligator juniper, were sawn down on the 104-acre watershed No. 6. Juniper stumps and small seedlings were sprayed with an herbicide to prevent regrowth. Shrub live oak and Gambel oak were also killed with herbicides.

Use of heavy machinery was avoided to keep from creating pits or other scars that might trap surface runoff. The area was seeded to grass, and grazing management was not changed.

Data collected after treatment will be analyzed to determine whether killing the trees and brush will increase streamflow.

Ponderosa pine
watershed clearcut

A 455-acre watershed, covered mostly with ponderosa pine trees, has been clearcut as a "benchmark" treatment to determine the most water that can be expected from treating this type of watershed. Data are being collected so that the effects of clearcutting on sediment yields, and timber, range, and wildlife values also can be determined.

All commercial wood products, such as poles, saw logs, and firewood have been sold, cut, and removed. Remaining trees and logging slash were bulldozed into windrows oriented to trap windblown snow, retain snow throughout the winter, reduce evaporation losses, and direct surface runoff into stream channels.

Snowpacks and water
yields manipulated
by strip cuttings

In the ponderosa pine forests of northern Arizona, north- and east-facing slopes trap and hold more snow for greater water yields during the spring runoff period. Results on west-facing slopes have been less favorable, and results on slopes with southern and southwestern exposures have been inconclusive.

Previous research in the Colorado Rockies has demonstrated that strip cuttings in forests increase water yields from snow by trapping and storing more snow until spring. Exploratory studies on the Beaver Creek watersheds are testing various widths of strips cut in forest stands, on slopes with different aspects, to determine which combinations should be put to a full-scale test on the pilot watersheds.

Northern Arizona watersheds receive precipitation in both summer and winter, but the greatest opportunities for increasing streamflow are through management to take advantage of the winter snowfall.

Thinned and unthinned
forests produce different
amounts of herbage

Ponderosa pine forests in northern Arizona that have been thinned generally produce different amounts of herbage (grasses, forbs, and so forth) than do unthinned forests supporting the same basal area of timber. At timber basal areas of less than 70 square feet per acre, a thinned forest produces more herbage than does an unthinned one. The slopes of the relationship curves (fig. E-1) were found to be significantly different. These differences

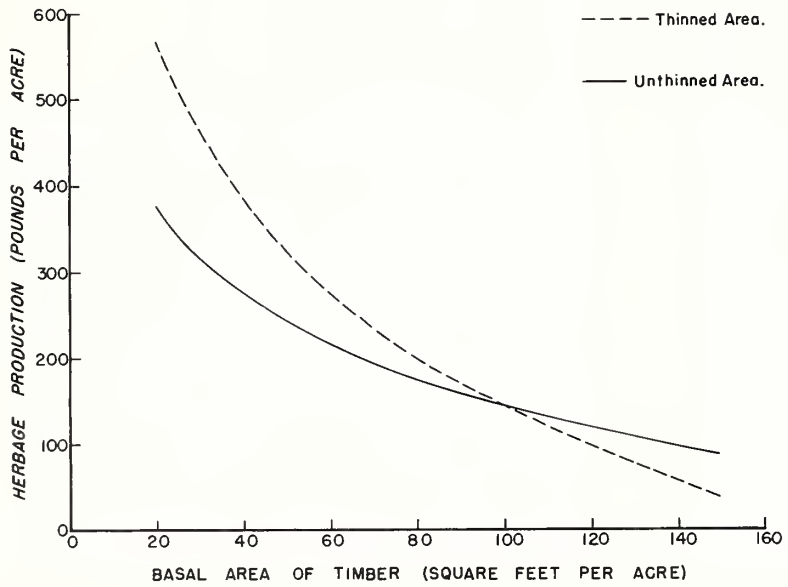


Figure E-1.--
Relationship between the herbage production and timber overstory on thinned and unthinned areas.

apparently are due to basic differences in site productivity.

Among the watershed treatments being considered for testing on the Beaver Creek Pilot Watersheds is thinning of ponderosa pine timber stands. As part of the multiple use evaluation of watershed treatments, we need to know how changes in forest stands affect the production of herbage within the forest. We now know that we cannot use herbage measurements in unthinned stands to predict herbage response to forest thinning treatments.

Forest Products Utilization

Untreated fenceposts
show early decay

Within only 5 years after they were set in the ground, some untreated fenceposts have begun to decay (fig. U-1). One post broke off under only 50 pounds of test load (fig. U-2). Posts treated with preservatives do not show signs of decay.

During 1960 and 1961, 975 fenceposts made from Black Hills ponderosa pine were installed at two test sites in South Dakota to determine the service life of treated and untreated pine fenceposts, both in the semiarid climate of the Great Plains and the more moist climate of the fringe of the Midwest. Thirteen combinations of types of treatments and levels of preservative retention are being tested.

Harnessed solar energy
dries lumber faster
and better

Continued comparisons of an experimental solar-heated dryer with conventional air drying have shown that the solar dryer (fig. U-3) does a better drying job and does it faster,

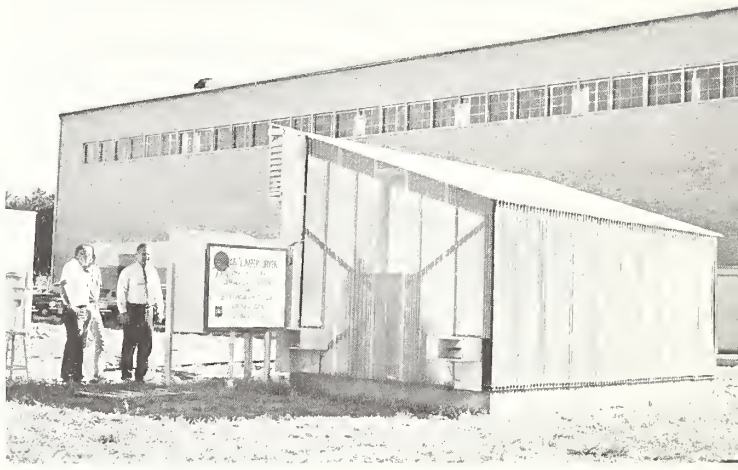
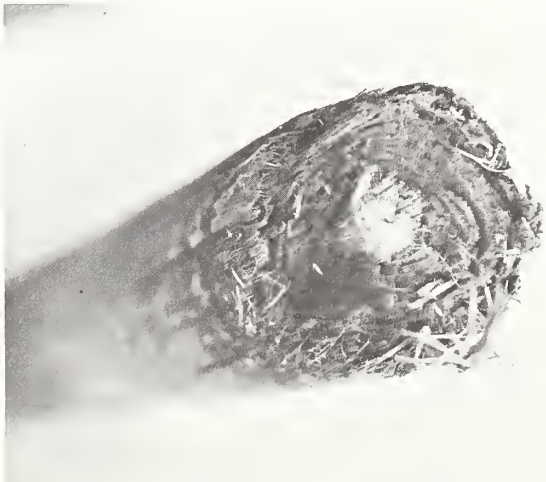


Figure U-3.--Experimental solar-heated lumber dryer used in tests at Colorado State University, Fort Collins, Colorado.

Figure U-1.--Typical ground line decay of untreated post at Midwest site.

Figure U-2.--Only post to fail a 50-pound pull test. This untreated post fractured 5 inches below ground line because of butt decay.



especially during cold or wet weather. The following average drying times were determined for 4/4 Engelmann spruce and lodgepole pine in Fort Collins, Colorado:

	Drying time by--	
	Solar dryer	Air drying
	(Days)	
To 19 percent moisture content:		
Fall	7	17
Winter	13	20
Spring	5	8
Summer	3	3
To 12 percent moisture content:		
Fall	13	27+
Winter	19	33+
Spring	10	15
Summer	6	9

Most lumber produced in the Rocky Mountain area is air dried in the mill yard. Some is dried in heated kilns. Use of solar energy has the potential of drying lumber faster and better than open air drying, and at less cost than kiln drying.

Compression wood increases after release

Release of forest stands by cutting some trees out (partial cutting) can substantially increase the incidence of compression wood in remaining trees that lean and make a growth response to their release. The incidence of compression wood in the remaining trees is strongly influenced by degree of lean. Lean appears to affect formation of compression wood more following release than before release (fig. U-4).

These conclusions were reached after analysis of data from an exploratory study of the effects of release or growth responses on formation of compression wood in ponderosa pine trees.

Compression wood causes economic losses due to warping and twisting of lumber and millwork. Research is underway to find out what causes compression wood to develop in a tree, and to devise a practical field method of detecting compression wood before the log is cut into lumber.

Extroctives couse variation in specific gravity of ponderoso pine

Extractive content is by far the most significant factor accounting for variability in specific gravity of ponderosa pine wood (fig. U-5). Other tree characteristics measured and tested add little to our ability to explain the variation. Extractives are the resinous or other infiltrated materials in wood cells that can be removed with solvents.

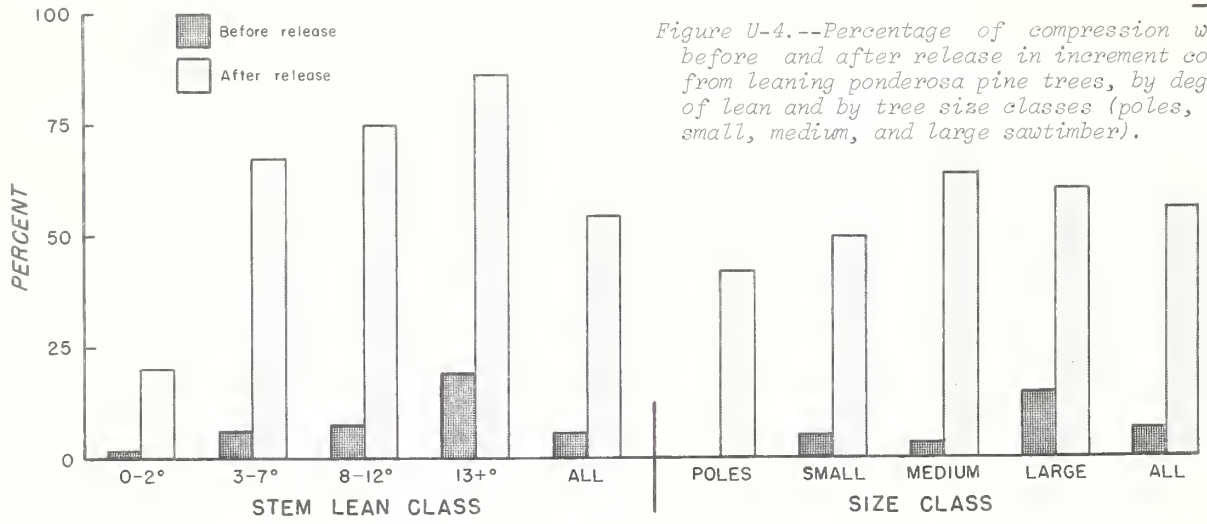


Figure U-4.--Percentage of compression wood before and after release in increment cores from leaning ponderosa pine trees, by degree of lean and by tree size classes (poles, and small, medium, and large sawtimber).

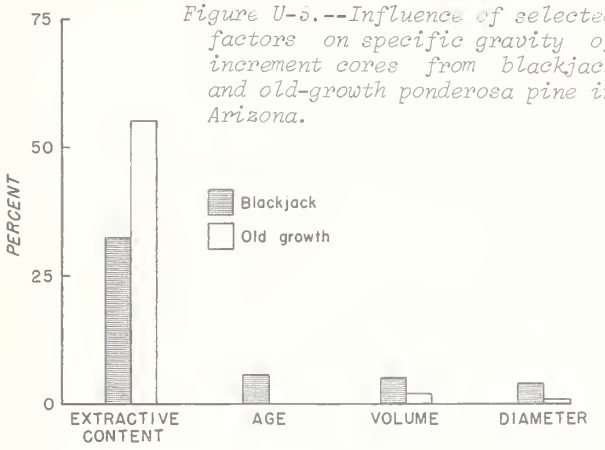


Figure U-5.--Influence of selected factors on specific gravity of increment cores from blackjack and old-growth ponderosa pine in Arizona.

Increment cores were taken from over 400 trees at three sample areas in Arizona, and analyzed for specific gravity and extractive content to determine how much extractives affect specific gravity in ponderosa pine.

Specific gravity (or density) is the simplest and most useful single index to the suitability of wood for many uses. It largely determines the yield of cellulose or pulp from a given volume of wood, and it is closely correlated with the mechanical strength of wood.

Ordinarily, variations in specific gravity are due to differences in basic characteristics and arrangement of cells as determined by tree species, size, age, growth rate, and environment. In some species, considerable variation may be due to differences in the resinous materials contained in the cells. Where extractives do influence specific gravity measurements, estimates of wood strength and pulp or cellulose yields will be too high.

Crook, sweep, and lean are most common defects in southwestern ponderosa pine stems

Data from about 9,000 acres of cutover ponderosa pine forests in north-central Arizona show that 19 percent of the trees have some crook in them, and 17 percent lean. Eighteen percent of the trees showed some sweep in the stem. Other stem form defects are less common: Forked stems occur in 5 percent, and fire scar, lightning scar, and damaged tops showed up in only about 2 percent of the trees.

The suitability of tree stems for use in most primary products is determined largely by the same few stem characteristics--sweep, crook, fork, scar, and aggregate knot or limbing features. Information about these stem characteristics makes it possible to determine the suitability of the timber for use in a variety of products.

In the Southwest most of the future timber will come from previously cut ponderosa pine stands (fig. U-6). This increasing dependence on cutover stands, plus a growing interest in product diversification, emphasize the need to know more about these timber stands.

Figure U-6.--Cutover stands of mature ponderosa pine contain a large proportion of the future Southwestern timber resource.

Forest Products Marketing

Nationol plywood morket characterized

In 1965 a total of 12,443 million square feet (3/8 inch equivalent basis) of softwood plywood was produced in the United States. Of the total, 87 percent was produced by plants in three West Coast regions. The Inland region produced 10 percent, and 3 percent came from the South.

The market areas of greatest interest to potential plywood producers in the Rocky Mountains and the Southwest are those centered on Denver, Salt Lake City, Phoenix, and El Paso. Plywood shipments into this part of the West, from the five producing regions, are shown in table M-1.

Data on plywood production and shipments in 1965 have been collected and analyzed in cooperation with the American Plywood Association. Plywood produced in all regions of the United States has been traced through shipments to 494 trade area destinations.

Much of the timber in the Rocky Mountains and the Southwest is of relatively low value for lumber, and the lower grades of lumber generally are being replaced in use by panel products such as plywood. Preliminary studies have shown that Rocky Mountain and Southwestern trees can be used for veneer and plywood production. The analysis of the national plywood market is the first step in appraising possible opportunities for development of a plywood industry.

Forest Recreation

Compground size, use, and costs reloted

A sampling of 21 forest campgrounds in Colorado showed that:

1. Costs of operation and maintenance (per family unit) are higher for the more heavily used campgrounds than for the lightly used ones.
2. Larger campgrounds tend to be less expensive (per family unit) to maintain and operate than are small ones.
3. Large campgrounds are not necessarily less expensive (per family unit) to build than are small ones. Other factors affect construction costs more than does the number of family units per campground.

Outdoor recreation developments and facilities on the National Forests are being used

Table M-1. --Plywood shipments from five producing areas into four selected western market areas in 1965[1]

Market area	Volume[1]	Source -- area of production				
		Puget Sound	Columbia River-Willamette Valley	California	Inland	South
	M sq.ft.[2]	Percent				
Denver	132,542	12	26	34	28	0
Salt Lake City	100,474	9	40	25	26	0
Phoenix	64,656	2	18	78	2	0
El Paso	17,862	2	28	58	6	6

[1] Based on data accounting for 70 percent of 1965 production in the United States.
[2] 3/8-inch thickness equivalent.

more heavily each year. Operating and maintaining existing areas and developing new ones require large amounts of manpower and money. Information on use of forest recreation facilities is expected to contribute to more efficient use of manpower and funds, and to improved service to the taxpaying public.

Camping trailers are popular—and affect chaice af campgraund

Forty-one percent of all campers sampled at forest campgrounds in Colorado in 1965 had travel trailers or tent trailers. Pickup-campers were used by 17 percent, while 38 percent used tents. Those using tents and pickup-campers used the near-highway and back-country sites about equally, but groups using tent trailers or travel trailers used campgrounds near highways twice as much as those back off the highways.

Wha gets the recreatianists' dallars?

Preliminary findings from a study of a stretch of the popular Poudre River Canyon in the Roosevelt National Forest in Colorado indicate that:

1. Most of the visitors to the Canyon came from Denver (about 100 miles) and other nearby urban centers along Colorado's Rocky Mountain front. They had traveled for more than 2 hours to get there, and were staying in the area for at least 1 night. The most popular outdoor recreation activities in the sample were fishing, camping, and general relaxation. Most of these visitors came primarily to enjoy the Canyon; they were not stopping on their way to some other recreation area.
2. Visitors, for the most part, spent little money at businesses located in the Canyon itself. Most families prepared for their trip at home and brought everything they needed with them. The main item of expense for the trip was the cost of automobile travel.

Use af campgraunds depends an lacatian

Forest campgrounds located near streams or lakes are used more than those not near water. The pleasing environment created by nearby streams and lakes has been found to be especially important in influencing use of campgrounds.

Amount of campground use is not affected by closeness to other campgrounds, urban areas, surfaced highways, or to through-travel routes. Neither is it affected by elevation above sea level.

In the Colorado Rockies, campers from Colorado make about equal use of sites near surfaced highways and the more out-of-the-way sites. Campers from other States, however, tend to use campgrounds nearest the highways most.

Neither campground size (total number of family units) nor amount of money spent per family unit to build the campground seem to influence the amount of its use.

These general conclusions were drawn as a result of a 1965 study of occupancy of 21 sample campgrounds in the National Forests in the Colorado Rockies.

Figure W-1.--
It is sometimes more economical to build a roof over the short stretch of a mountain highway threatened by an avalanche than it is to build the supporting structures necessary to stabilize the snow in the starting zone.

Figure W-2.--This high-voltage transmission tower, at the lower edge of the runout zone of an infrequent avalanche, is protected by a reinforced sheet metal wedge backfilled with rock.

Structural control of avalanches

As techniques improve, structural control of avalanches is expected to expand rapidly in the Western United States. Climax Molybdenum Company has installed control structures in the starting zone of a small avalanche that threatens a mining operation near Climax, Colorado. A large earthen dam, built farther downslope where the slope is more gentle, crosses the avalanche path to stop any avalanches that start below the structures.

Avalanche control structures in the runout zone (figs. W-1, W-2) are more suitable for some situations than supporting structures in the starting zone.

Internal structure of mountain snowpack is key to avalanche behavior

Each storm of the winter deposits a new layer of snow in avalanche starting zones. This deposited snow undergoes constant change due to the weight of new layers, the temperature gradient within the snow, and wind action. This metamorphism of the snow ultimately determines the stability of the snowpack and the possibility of avalanches.

Data gathered from snow pits at Berthoud Pass, Colorado, over the past 16 winters (fig. W-3) show that metamorphism soon masks the numerous snow layers, and that the snow in avalanche areas consists of three basic lay-

Figure W-3.--Berthoud Pass study area on the west side of the Pass. The avalanche sites, numbered A-1 through A-5, show locations where the snowpit data were taken periodically from 1950-66 to determine slope stability. Bimonthly snowpits are dug at the level test field, called Q-12 Park (T-1). Precipitation and temperature are also recorded daily at T-1.

ers. The bottom layer consists of unstable crystals of depth hoar, significant in the formation of avalanches because of their low cohesion. The middle layer is composed of high-strength, fine-grained crystals whose cohesion promotes the formation of dangerous hard-slab avalanches. This type of avalanche tends to rupture over a large area. The surface layer consists of new and settled powder snow, which has low strength but enough cohesion to form soft-slab avalanches. This type of avalanche usually slides on the older snow of the middle layer.

During early winter in Colorado, most avalanches involve all three layers and run on the ground. Later in the season, it is more common for just the top layer to avalanche and run on top of the older metamorphosed snow.

Analysis of the snow in avalanche starting zones at Berthoud Pass shows that:

1. The extent and thickness of the depth hoar layer in starting zones may be determined by using a ram penetrometer, which eliminates the necessity of digging full-depth snow pits.
2. It takes 20-30 days with temperature gradients of -0.16°C. per centimeter to transform the snow near the ground into depth hoar.
3. Avalanches that slide on the middle or lower layer outnumber those that slide over the ground by three to one.

Intercepted snow blows into small openings

Deepest snow in small openings in the forest, less under trees, and least in open country is the usually reported distribution of snow. The retention and subsequent evaporation of snow striking tree foliage is often given as the reason for less snow under the trees than in forest openings. Recent results from Fraser Experimental Forest in the Colorado Rockies indicate that the greater snow in openings in the forest than under trees represents transport of snow from trees to openings rather than evaporation losses.

Direct observation and timed movie sequences showed how snow accumulated on foliage and how long it was retained. There was no evidence of snow adhering to foliage. Snow built up by the cohesion of snowflake to snowflake, beginning with small masses held on branches and at bases of needles (fig. W-4). Snow was only weakly held on the tree crown, and was easily removed by wind. Trees were snow covered the longest during cold, cloudy periods with frequent snowfall.

Figure W-4.--

The first snow held on lodgepole pine foliage is supported on branches and at the base of needle bunches. It does not adhere to the needles, but rather glides along them until it reaches a point of support.

As snowfall continues, snow builds up in the foliage. The individual snow crystals cohere to one another, and are most strongly bonded when they accumulate to depths greater than the needle length. The snow within the needle space tends to sift out, leaving a snow slump balanced on the ends of needles.

Figure W-5.--Rime (ice from freezing of supercooled water drops) sometimes forms on trees. Rime is tightly held on foliage, in contrast to snow crystals. When mixed with snow, it glues snow into its mass, and may build tree-breaking loads. It is important to distinguish rime from snow in interception studies.

Rime ice can greatly increase snow accumulation on trees

Many of the Christmas-card type photographs of trees heavily plastered with snow (fig. W-5), and the cases of heavy snow breakage of trees, are the result of rime or mixed rime and snow accumulation. Rime forms when supercooled water droplets or fog freeze upon exposed objects. In some areas, rime formation is intermixed with snow, and the ice actually pastes snow to tree foliage. Massive snow accumulations can then occur, and may persist for long periods. Rime is frequent in the Sangre de Cristo Mountains near Santa Fe, New Mexico, where we are evaluating its significance.

Snow redistribution affects runoff

Comparisons of snowpack in the alternate forest and clearcut strips in the Fool Creek watershed on the Fraser Experimental Forest indicate there are about 4 inches more snow water in the small clearcut patches. Despite this difference, there seems to be no increase in the total snow storage on the watershed. There is a pronounced redistribution of snow as a result of the cutting, and now there is about 2 inches less snow under remaining forest patches and 2 inches more in the cut patches than before cutting.

This redistribution of snow is probably an important cause for increased runoff resulting from the treatment. The concentration of snowpack on portions of the watershed increases the efficiency of delivery of water to stream courses and ground-water storage. Also, initial soil-moisture deficiencies are least where the forest has been cut. Less water is needed to recharge soil moisture in the spring, and there is more available for streamflow.

Finally, snow melts more rapidly in the clearcut openings than in the forest, and is thus exposed to evaporation for a shorter time.

Forest openings for snow trapping

Because redistribution is more important than vaporization of intercepted snow, a pattern of forest and opening is necessary for maximum water yield. The patterns most effective for maximizing runoff of snowpack water will have intermingled forest and opening arranged to minimize air turbulence in the openings. Openings larger in diameter than 10 tree heights appear less efficient than smaller openings. Theoretically, trapping efficiency decreases rapidly as openings exceed 10 tree heights, and large openings will hold less snow than the surrounding forest.

Two-level wind system influenced by vegetative cover

A series of measurements made at Fraser Experimental Forest in June concluded a study of a complex and striking local forest wind system: The nighttime cold-air drainage on a steep, forested hillside, typical of many Rocky Mountain watersheds. Measurements made with sensitive wind-cup anemometers, and later with the heated thermistor anemometers developed this past year, show a microscale two-level system. Winds overlying the forest floor and the average canopy surface sometimes reached more than 10 miles per

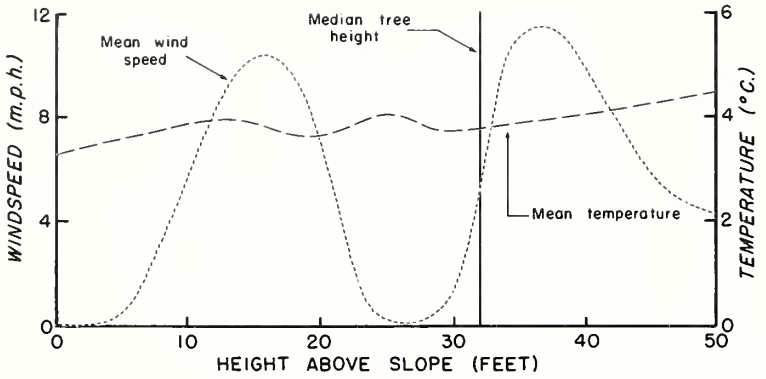


Figure W-6.--
Mean windspeeds and temperatures at a midslope station on a typical night, Fraser Experimental Forest. Readings taken June 16, 1966, 2000-2200 hours local standard time.

hour, but were separated by a layer with concurrent speeds less than one-fourth mile per hour (fig. W-6). These flows, representing a tremendous flux of moisture into the low-lying areas of such terrain, appear to be strongly influenced by the vegetative cover, and thus can probably be manipulated by cutting patterns.

Forested watersheds trap radioactive particles

Forested watersheds remove and retain radioactive particles contained in snowmelt water. Measurements of gross beta activity were included in an assessment of water quality associated with stream, bog, and ground-water locations at a small mountain bog. The bog and forest litter in timbered land above the bog are efficient filters that screen out most radionuclides contained in snowmelt water. The gross beta activity of effluent stream water was much less than that of snow water (fig. W-7). Additional screening also occurred in the ground-water aquifer. Gross beta activity of groundwater increased sharply in September when the water table was at a seasonal low. The high beta activity was coming from aquifer sediments enriched by radionuclides filtered from ground water.

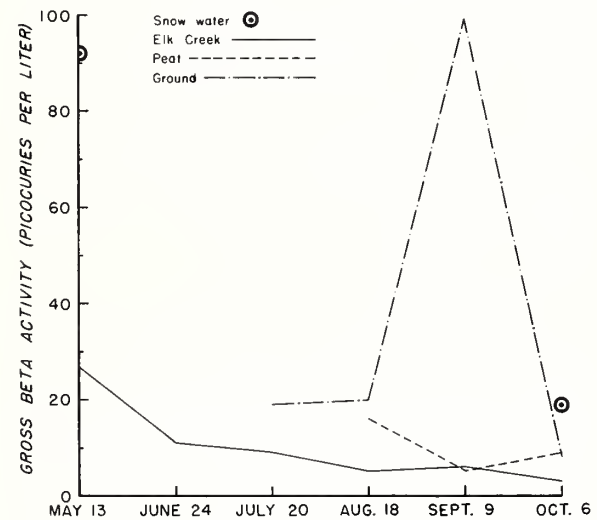


Figure W-7.--
In Wyoming, low beta activity of creek water below a mountain bog shows filtering effectiveness of the bog and forest litter.

Rock check dams for gully control

Recent trials on the White River National Forest in western Colorado have proved the value of rock check dams in modern gully control (fig. W-8). Double-fence structures provided control at least expense, compared with loose-rock, wirebound, and single-fence dams. Higher double-fence dams are more economical on gully gradients steeper than 5 percent.

Because mechanized equipment could be used to handle the rock (fig. W-9), hand labor ranged from only 2 to 8 percent of the total cost.

Reduced transpiration does not offset rainfall interception by conifers

Interception of rainfall on vegetation has long been thought to result in a significant

loss of water from the site to the atmosphere. Some recent studies of grass and other herbaceous plants, however, have indicated that wetting the foliage reduces transpiration almost enough to compensate for the evaporation of the intercepted water.

That interception of rainfall by pine and spruce trees does result in a real loss of water has now been shown by a study of small potted trees under simulated rainfall in an outdoor environment.

Transpiration is reduced during the period when the foliage is wet, but the saving is very small compared with the amount of water intercepted and evaporated. Of the amount intercepted, 94 percent was lost back to the atmosphere, with only 6 percent saved to the site through a reduction in transpiration.

While the needles are wet the rate of evapotranspiration is much greater than the rate of transpiration from unwetted foliage. This is explainable through three factors: (1) The radiant energy available for vaporization of water is 12 percent greater with wet foliage than with dry (fig. W-10); (2) the wet foliage is cooler than the dry so that more heat can be absorbed from the air (fig. W-11); and (3) most important, the energy required for evaporation from a free water surface is much less than that to transpire water through the stomates of a pine or spruce needle.

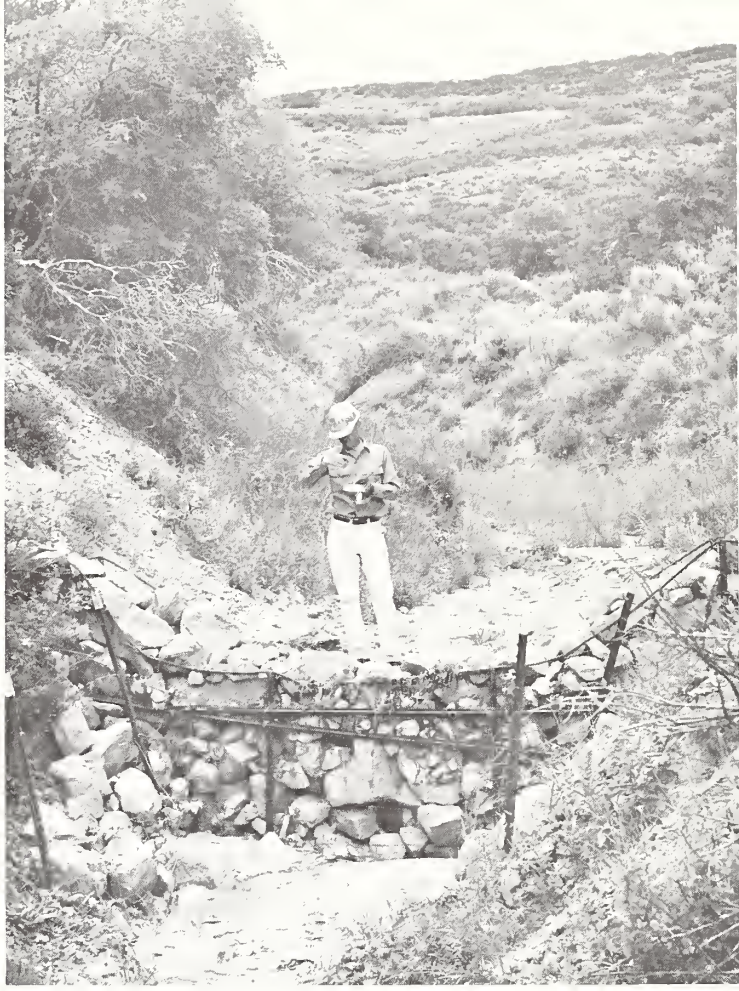


Figure W-8.--
A double-fence dam after the snowmelt season. The catchment basin of the dam is filled with sediment to the crest of the spillway, and vegetation is invading the deposits.

Figure W-9.--
A clam shell empties rock into a double-fence structure.

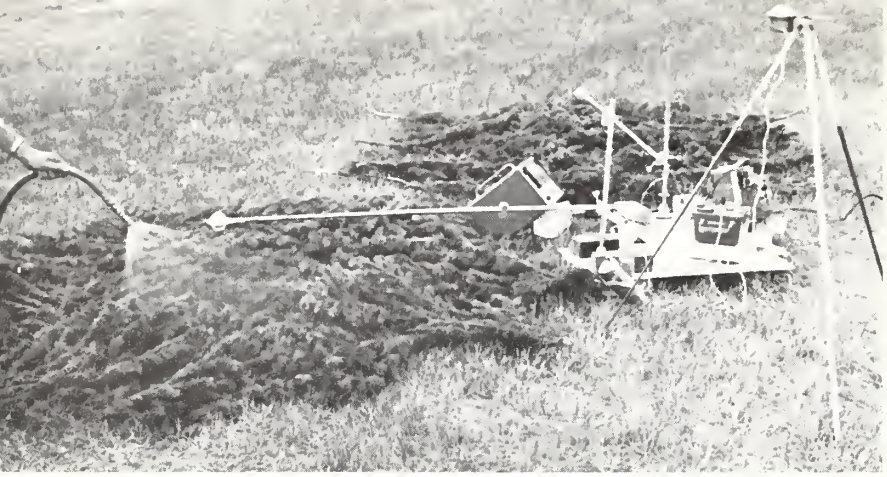


Figure W-10.--
Measuring the radiation balance over wetted and unwetted spruce foliage.

Figure W-11.--
Measuring the temperature of spruce foliage by means of an infrared thermometer.

Techniques for measuring transpiration

A method is being tested for collecting water vapor from an airstream with a desiccant or a refrigerant to measure transpiration. One airstream passes through a Plexiglas cylinder containing a plant, and the other through an identical cylinder which is empty (fig. W-12).

Three basic equipment designs involving adsorbents or refrigerants and intermittent or continuous airflow systems were developed and tested. Maximum percentage errors for the three systems over a range of moisture losses were $\pm$ 5 percent to $\pm$10 percent. The accuracy of the methods, therefore, appears to justify confidence in their use.

Some advantages of the method are:

1. It is straightforward.
2. It gives an absolute measure of water loss.
3. It gives an integrated value of water loss over a period of time.

Figure W-12.--
Apparatus for measuring transpiration by adsorption from a continuous air flow.

4. It measures transpiration from an intact branch.
5. By using a single branch or shoot, the leaf area or weight of the tested portion of the plant can be accurately determined, thus providing a common basis for comparing plants.
6. Plants of all sizes can be tested. Since only a single branch or shoot is tested, the method is not limited by the size of the plant.

Knowledge of the transpiration characteristics of watershed plants can be valuable in controlling transpiratory water losses. The approach will be to reduce the transpiratory water loss from plants by means of chemicals.

The three main objectives of the transpiration research program are: (1) To develop and investigate methods of measuring transpiration, (2) to obtain knowledge of the transpiration characteristics of native watershed plants and replacement species, and (3) to reduce the transpiratory water loss from plants by means of chemical treatments.

Additional treatments started on Workman Creek, Arizona

The North and South Forks of Workman Creek, on the Sierra Ancha Experimental Forest, are being studied to determine the effects of selective timber cutting versus clearcutting as a means of increasing water yield. When 80 acres of moist-site trees were cleared on the North Fork in 1958, annual water yield increased 52 percent. Removing 46 percent of the merchantable timber on the South Fork did not significantly increase water yield.

Now, additional ponderosa pine on the North Fork is being removed, so that about half the total watershed area will be clearcut and planted to grass (fig. W-13). The present pine-fir forest on the South Fork will be harvested to a basal area of 40 square feet of pine per acre. The objective on North Fork is to determine, by progressive steps of vegetation removal, how much water is used by various forest types, and what effect their removal has on water and sediment. On the South Fork, the objective is to determine the minimum amount of forest cover necessary for adequate timber production and maximum production of water.

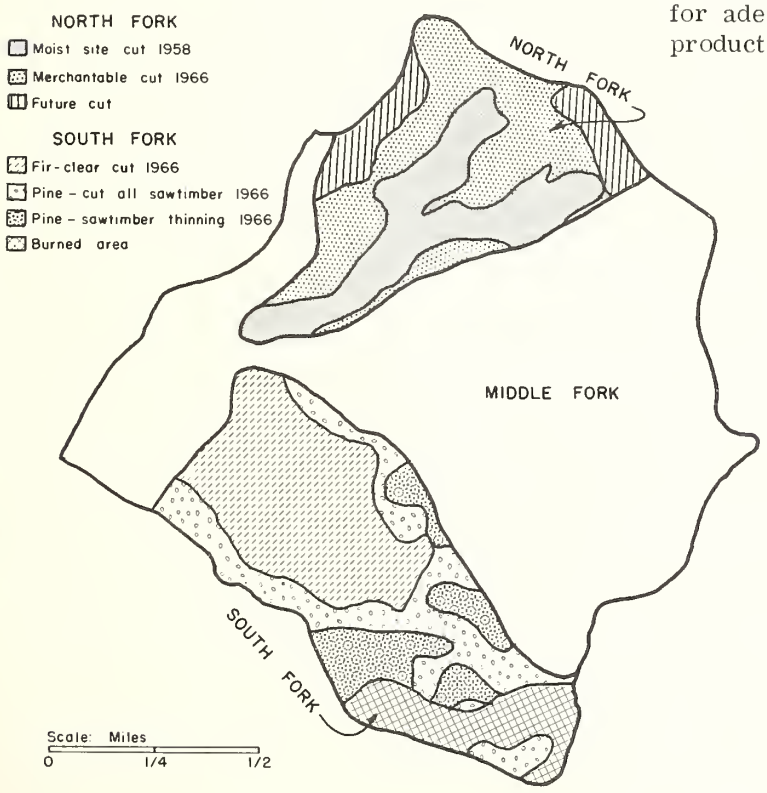


Figure W-13.-- Proposed treatments on Workman Creek Experimental Watersheds.

Draught mast impartant factar in shrub live aak seedling martality

In a burned chaparral area of the Sierra Ancha Experimental Forest, Arizona, shrub live oak seedling survival was 30 percent after 2-1/2 years. Mortality rate has leveled off, suggesting that most shrubs now living may survive unless climatic conditions are unusually severe. Only one of 66 seedling deaths was definitely attributed to rodent damage; other mortality appeared due to drought. Shrub live oak seedlings become established only in infrequent years when a good acorn crop is followed by unusually high summer rainfall.

Alkali sacatan affected mast by maisture stress

Seeds of alkali sacaton, galleta, and blue grama were germinated in media representing moisture tensions of 0, 1, 4, 7, 10, 13, and 16 atmospheres (fig. W-14). Alkali sacaton germination was most severely affected by moisture stress, which helps to explain, at least in part, why alkali sacaton plants are confined mainly to areas that are frequently flooded. In contrast, galleta and blue grama are less specific with respect to level of moisture necessary for maximum germination and vigorous seedling growth, and can therefore become established and survive on drier upland sites.

Faliage sprays af piclaram may help cantrol water lass fram plants

Picloram may play a major role in reducing water use by shrub live oak growing on a watershed, without actually killing the plants and exposing the soil to erosion.

Greenhouse tests have shown that soil applications of picloram, as well as high-volume foliage sprays, inhibit growth and water use but cause only minor damage to leaves. A leaf- and stem-wetting spray (2 pounds per 40 gallons of water) had a much greater effect on transpiration than a low-volume spray. Leaf injury lagged behind transpiration reduction; for a short time the difference between them was about 40 percent, or twice the difference obtained with a low-volume spray.

Plants sprayed in a laboratory spray tower with a low-volume spray (1/2 pound per acre in 10 gallons of water) reduced transpiration 22 percent without injury to the leaves. The duration of the inhibition was short, however, and additional treatments were necessary to maintain inhibition. Repeated sprays caused greater leaf injury.

Several chaparral shrubs are injured more rapidly by picloram than is shrub live oak. Treatment of plants less sensitive to the injurious effects of picloram, however, may produce important water savings without serious erosion hazard.

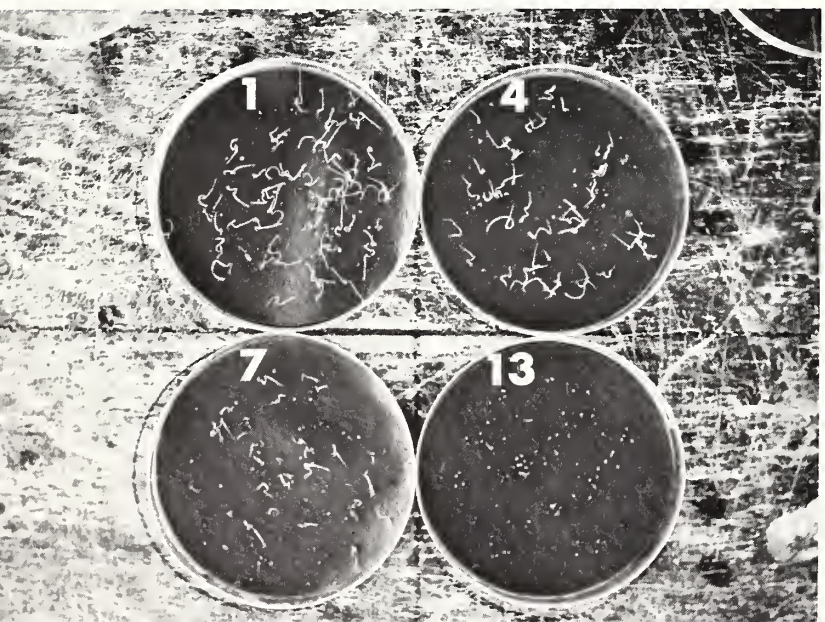


Figure W-14.--
Germination of alkali sacaton under 1, 4, 7, and 13 atmospheres of moisture tension.

Fenuron storves shrubs indirectly

Although starvation is the ultimate cause of death of fenuron-treated shrubs, recent experiments indicate it is not the direct cause of original leaf injury. Tests show leaf injury begins before energy reserves of the plant are exhausted.

Recent studies indicate a phytotoxic chemical accumulates in the leaf as the result of a blocked reaction during photosynthesis. This toxic accumulation is directly responsible for leaf injury. Starvation of the shrub, then, depends on its food reserves, and may extend over a period of years. Successful field treatment of shrubs will thus depend on balancing the rate of loss of fenuron from the soil against stored plant food reserves. Low-reserve plants should be easier to kill.

Shrub live ook killed with soil-opplied herbicides

Chaparral shrubs on northerly slopes and channel bottoms were treated with soil-applied herbicides in January 1965 on the Three-Bar Experimental Watersheds, Tonto National Forest, Arizona.

Shrub live oak, the most abundant shrub, was satisfactorily controlled on one area of the watershed with Tordon at 8 pounds acid equivalent per acre; on another area, with fenuron, at 16 pounds. Tordon was especially effective against several secondary shrub species, notably birchleaf cercocarpus, sugar sumac, and yellowleaf silktassel.

While it is too soon to draw firm conclusions about increase in water yield due to this treatment, the normally ephemeral streamflow has been continuous since the treatment was applied.

Rio Puerco soils found deficient in soil nutrients

Soil nutrient deficiencies have been found in some of the flood plain soils of the upper Rio Puerco drainage area in New Mexico. When a complete fertilizer including micronutrients was applied, native grass stands increased growth and basal area.

Alkali sacaton, when grown on the same soil in the greenhouse, responded to phosphorus and to a combination of nitrogen and phosphorus (fig. W-15). Sacaton also responded to zinc when it was applied in combination with nitrogen and phosphorus, but not when applied alone. The greenhouse tests gave an indication of a possible response to sulfur when applied with nitrogen and phosphorus, but the results were not conclusive.

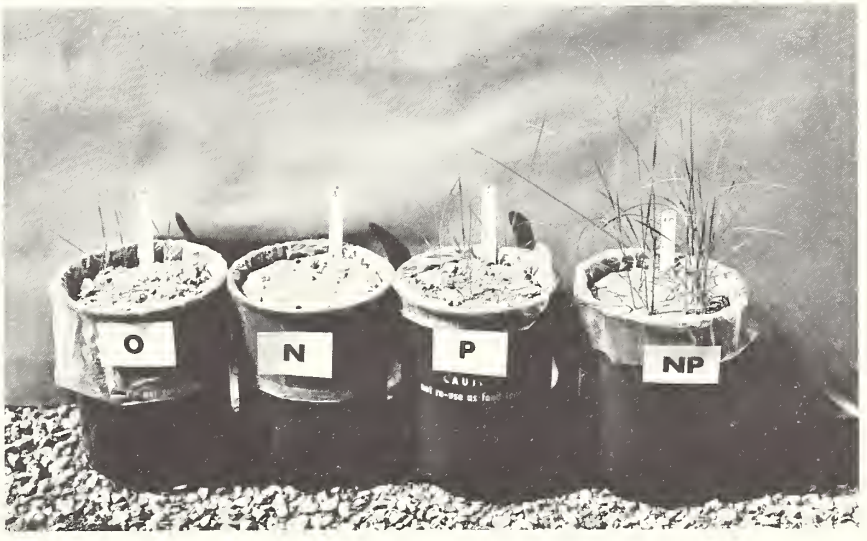


Figure W-15.--Alkali sacaton responds to phosphorus (P) and to a combination of nitrogen and phosphorus (NP) on soil from a flood plain of the upper Rio Puerco drainage area. The check plot (O) and nitrogen only (N) are also shown.

Publications

Aldon, Earl F.

Deferred grazing and soil ripping improves forage on New Mexico's Rio Puerco drainage. N. Mex. Stockman 31(11): 44, 46.

Summer-deferred grazing significantly increased the ground-cover index and reduced sediment yields on the Rio Puerco drainage. Soil ripping also increased forage production. Largest gains in plant cover occurred on alluvial flood plains growing alkali sacaton.

Alexander, Robert R.

Establishment of lodgepole pine reproduction after different slash disposal treatments. U. S. Forest Serv. Res. Note RM-62, 4 pp., illus.

Five years after clearcutting, stocking varied with seedbed condition, but slash density had little influence. Because of uniform distribution of seedlings, burned seedbeds were considered to have best stocking.

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Harvest cutting old-growth lodgepole pine in the central Rocky Mountains. J. Forest. 64: 113-116, illus.

Clearcutting is recommended for bringing old-growth lodgepole pine under management. Reproduction is abundant and well distributed, and windthrow losses are avoided.

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Site indexes for lodgepole pine, with corrections for stand density: Instructions for field use. U.S. Forest Serv. Res. Paper RM-24, 7 pp., illus.

Figures and tables are presented for estimating corrected site index of lodgepole pine. Site indexes are adjusted for stand density on the basis of data from Colorado, Wyoming, Utah, Idaho, Montana, and eastern Washington and Oregon. Methods used to develop the curves will be in a subsequent paper.

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Stocking of reproduction on spruce-fir clearcuttings in Colorado. U.S. Forest Serv. Res. Note RM-72, 8 pp., illus.

Stocking on 200- to 400-foot wide clearcut strips was determined on 99 cutting units on 8 National Forests. Stocking will insure an adequate replacement stand on all cutting units examined. Stocking to new reproduction was related to seedbed condition, aspect, slope, amount of slash, vegetative abundance, soil texture, width and direction of cut strip, and the number of years since cutting.

Blankenship, James O.,* and Smith, Dixie R.

Indirect estimation of standing crop. J. Range Manage. 19: 74-77.

Criteria such as density and cover are correlated with standing crop of alpine species. Use of these varieties, however, in a double sampling design was less efficient than a single clipped sample of equal cost.

Boeker, E. L.,* and Reynolds, Hudson G.

Deer and elk habitat improvement studies in southern New Mexico. N. Mex.-Ariz. Sect. Wildlife Soc. Proc. 5: 29-35, illus.

Summarizes preliminary findings, and describes design for an intensive study of vegetation-game use relations on an experimental area in southern New Mexico.

*Private, State, or Federal cooperator.

Cable, Dwight R.

Competition between burroweed and annual and perennial grasses for soil moisture. Amer. Forage and Grassl. Counc. Proc. 1966: 11-27, illus.

Because burroweed has a taproot and is primarily a spring grower, summer yields of annual and perennial grasses were only moderately affected by burroweed. Perennial grasses competed strongly with annual grasses and burroweed during the summer growing season.

_____ and Shumway, R. Phil.*

Crude protein in rumen contents and in forage. J. Range Manage. 19: 124-128, illus.

Rumen-fistulated steers consistently selected a diet higher in protein than hand-clipped samples of the major available perennial grasses. The excess rumen protein depended on availability of higher protein shrubs and annual forbs.

Campbell, C. J.

Periodic mowings suppress tamarisk growth, increase forage for browsing. U.S. Forest Serv. Res. Note RM-76, 4 pp., illus.

Tamarisk was clipped (completely defoliated) and mowed at 2-, 4-, 8-, and 24-week intervals throughout the growing season. Plant mortality increased with frequency of clipping. Plants were not killed by the 1 season of mowing, but dry foliage yields were similar to yields produced by clipping treatments. In central Arizona, mowings in May, July, and September are necessary to keep foliage succulent and within reach of browsing cattle. Evapotranspiration decreased approximately 50 percent following mowing treatments.

Chansler, J. F.

Cold hardiness of two species of Ips beetles. J. Forest. 64: 622-624, illus.

Ips confusus, infesting pinyon pine in Arizona and New Mexico, can successfully withstand 5^{O} to 10^{O} colder temperatures than Ips lecontei, a pest of ponderosa pine in central and southern Arizona.

Choate, Grover A.*

New Mexico's forest resource. U.S. Forest Serv. Resource Bull. INT-5, 60 pp., illus.

First comprehensive inventory of New Mexico's 18 million acres of forests, of which 6 million acres are commercial forest land, presents statistics on area, volume, growth, mortality, and timber use; describes species, volumes per acre, stocking, site quality, ownership, trends in product harvesting, and other factors bearing on timber management; makes comparisons with other States in the Rocky Mountain area; discusses future-development problems--timber markets, roads, stand improvement, coordination of uses, and management of small private holdings.

Clary, Warren P., and Ffolliott, Peter F.

Differences in herbage-timber relationships between thinned and unthinned ponderosa pine stands. U.S. Forest Serv. Res. Note RM-74, 4 pp., illus.

Herbage production under the thinned stands was significantly greater than under unthinned stands for given timber basal areas of less than 70 square feet per acre.

_____, Ffolliott, Peter F., and Zander, Almer D.*
Grouping sites by soil management areas and topography. U.S. Forest Serv. Res. Note RM-60, 4 pp., illus.
Land strata for reducing sampling variance for both herbage production on areas cleared of timber and site index on timbered areas, were designed for use on the Beaver Creek watersheds. The strata can be delineated by use of soil maps, aerial photographs, or topographic maps, and limited ground checks.

Currie, Pat O.
Marking cows with human hair dye. J. Range Manage. 19: 306-307, illus.
Large, easily applied numbers could be read at considerable distance for the life of the hair coat--150 to 180 days when applied in the fall.

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Seeded range improves calf weaning weights and profits. Colo. Rancher and Farmer 20(6): 5, illus.
Over the past 3 years, average weaning weights have been increased 32 pounds, with an added gross income of $7.70 per calf, by incorporating seeded ranges into the livestock management system.

_____ and Goodwin, D. L.*
Consumption of forage by black-tailed jackrabbits on salt-desert ranges of Utah. J. Wildl. Manage. 30: 304-311, illus.
Species preference of jackrabbits closely followed that of domestic sheep; 5.8 jackrabbits equaled 1 sheep in forage consumed or wasted during the normal winter use period.

_____ and Peterson, Geraldine.
Using growing-season precipitation to predict crested wheatgrass yields. J. Range Manage. 19: 284-288, illus.
Forage production available for use by livestock varies with the season in which ranges are used. Specific precipitation patterns accounted for 87 percent of these differences in forage yields.

Davis, Edwin A.
The role of starvation in fenuron injury to shrub live oak. Weeds 14: 10-17, illus.
Although leaf injury appears to be due to components in a toxic oxidized state as a result of a block in the oxygen-liberating system, the entire plant ultimately dies of starvation.

Dietz, Donald R., and Curnow, Richard D.
How reliable is a forage chemical analysis? J. Range Manage. 19: 374-376, illus.
Material collected from aspen (Populus tremuloides Michx.) and mixed meadow grasses (mostly Poa pratensis L. and Phleum pratense L.) was sent to four nutrition laboratories for chemical analysis. Results obtained were closely comparable in most cases, but some discrepancies were noted, especially for one laboratory.

Dubin, H. Jesse,* and Staley, John M.
Dothistroma pini on Pinus radiata in Chile, U. S. Agr. Res. Serv. Plant Dis. Rep. 50: 280.
D. pini was found to be causing severe damage to a 9-year-old plantation; apparently the first observation of D. pini in Chile.

Evans, Keith E.
Observations on a hybrid between the sharp-tailed grouse and the greater prairie chicken. Auk 83: 128-129, illus.
A male hybrid was repeatedly observed in Yuma County, Colorado. Characteristics and behavior were divided between the two parent genera.

Frank, Ernest C., and Lee, Richard.
Potential solar beam irradiation on slopes: Tables for 30° to 50° latitude. U.S. Forest Serv. Res. Paper RM-18, 116 pp.
True solar time of sunrise and sunset and daily integrated potential insolation are presented in a series of tables for surfaces from latitudes 30° to 50° north, by 2° increments; at aspects from 0 to 360°, by 22.5° increments; on slopes from 0 to 100 percent, by 10-percent increments; and for 13 solar declinations or 24 dates during the year.

Frutiger, Hans,* and Martinelli, M. Jr.
A manual for planning structural control of avalanches. U.S. Forest Serv. Res. Paper RM-19, 68 pp., illus.
Classifies avalanches for control work. Control structures include supporting structures and wind baffles in the starting zone; diverting, guiding, retarding, and catching structures in the track; and direct-protection structures in the runout zone. Outlines field observations and design specifications necessary for planning a control project, and develops a control plan for a specific avalanche.

Galt, H. D.,* Theurer, Brent,* Ehrenreich, J. H.,* Hale, W. H.,* and Martin, S. Clark.
Botanical composition of the diet of steers grazing a desert grassland range. West. Sect., Amer. Soc. Anim. Sci. Proc. 17: 397-401. (Abstract in J. Anim. Sci. 25(2): 598.)
Results showed steers were very selective in their choice of plant species available. Botanical composition of diet, as determined by analyses of rumen contents, varied with time, and was not closely related to plant availability or productivity.

Goodell, B. C.
Snowpack management for optimum water benefits. ASCE Water Resources Eng. Conf. Preprint 379, 14 pp.
Snowpack accumulation and melt can be managed in several ways to benefit quantity and timing of water yield. Partial logging of a Colorado mountain watershed increased annual water yield 20-30 percent over a 10-year period.

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Watershed treatment effects on evapotranspiration. Int. Symp. Forest Hydrol. Proc. 1966: 477-482. Oxford & New York: Pergamon Press.
Watershed treatments affect evapotranspiration to the extent that they cause maladjustments between the flukes of water and energy. Forest cutting must be severe enough to produce effective and persistent discontinuities in the canopy surface and/or the root network.

Greenham, C. G.,* and Hawksworth, F. G.
Known and potential hazards to forest production by the mistletoes and dwarfmistletoes. FAO/IUFRO Symposium on internationally dangerous forest diseases and insects. Meeting No. V. Oxford, July 20-30, 1964, 11 pp.
A review of mistletoes as a worldwide problem affecting forest production. Lists most damaging mistletoes and their hosts. Published proceedings has each paper in three languages, and each separately paged.

Hansen, Edward A.
Field test of an automatic suspended sediment pumping sampler. Trans. ASAE 9: 738-741, 743, illus.
Describes performance of sampler under conditions of ephemeral streamflow, with direct-current power supply. The proportion of sand-size material varied from 0 to 55 percent.

Hawksworth, Frank G., and Wiens, Delbert.
Observations on witches'-broom formation, autoparasitism, and new hosts in Phoradendron. Madrono 18: 218-224, illus.
Phoradendron tomentosum subsp. tomentosum is reported causing witches'-brooms on Fouquieria fasiculata in Durango, Mexico. Host relationships recorded

for the first time are P. villosum subsp. coryae on P. juniperinum and Condalia globosa. Autoparasitism is reported in P. californicum and in P. tomentosum subsp. tomentosum. The parasitism of Larrea divaricata by P. californicum is not so rare as previously supposed.

Hayes, G. Lloyd.

Providing for optimum regeneration in the logging plan--east side. West. Forest. and Conserv. Ass., West. Reforest. Coord. Comm. Proc. 1965, 4 pp.

The overall problem is to get an adequate seed supply onto a well-prepared site before other vegetation can take it over. A complete plan is required, to include logging, pest control, slash treatment, site preparation, etc.

Heede, Burchard H.

Design, construction, and cost of different types of rock check dams. U.S. Forest Serv. Res. Paper RM-20, 24 pp., illus.

Loose-rock, wire-bound, single-fence, and double-fence rock check dams and one type of head-cut control were designed and installed in gullies on the White River National Forest, Colorado. Gully control was least expensive with double-fence dams. Higher double-fence dams are more economical on gully gradients steeper than 5 percent.

Hickey, Wayne C., Jr., and Springfield, H. W.

Alkali sacaton: Its merits for forage and cover. J. Range Manage. 19: 71-74, illus.

Alkali sacaton provides fairly abundant forage, is an effective ground cover, withstands relatively heavy grazing, and may offer possibilities for reseeding. It probably is a more valuable grass than generally realized, and merits more attention and research.

Hinds, Thomas E., and Hawksworth, Frank G.

Indicators and associated decay of Engelmann spruce in Colorado. U.S. Forest Serv. Res. Paper RM-25, 15 pp., illus.

On a board-foot basis, Fomes pini punk knots or sporophores caused an 81 percent deduction. Deduction for broken tops or dead tops with adjacent dead rust brooms amounted to 24 percent. Basal wounds, dead rust brooms, a dead leader, frost cracks, all forks, joined at the base to another tree, spike top, and trunk wounds were each responsible for a 10 percent deduction. Fomes pini was the most important decay fungus.

_____ and Peterson, Roger S.

Antibiotic tests on western gall rust and aspen cankers. U.S. Agr. Res. Serv., Plant Dis. Rep. 50: 741-744, illus.

Cycloheximide (Acti-dione) and Phytoactin at concentrations of 200 p.p.m. temporarily reduced canker fruiting, but there was insufficient translocation to affect fruiting above the sprayed area. Cycloheximide at concentrations of 300 p.p.m. failed to inhibit sooty-bark, Cytospora, Hypoxylon, or Ceratocystis cankers of aspen.

Hoover, Marvin D., and Leaf, Charles F.

Process and significance of interception in Colorado subalpine forest. Int. Symp. Forest Hydrol. Proc. 1966: 211-222, illus. Oxford & New York: Pergamon Press.

Observations of snow accumulation and retention on lodgepole pine and Engelmann spruce indicate that mechanical removal and transport of intercepted snow are more important than vaporization. Conclusions are based on examinations during snowstorms and on a timed-sequence movie film throughout the winter of 1963-4 at the Fraser Experimental Forest, Colorado.

Horton, Jerome S.

Vegetation management on flood plains and riparian lands. I. Problems of land management in the various phreatophyte zones. Pacific Southwest Inter-Agency Comm., Phreatophyte Symp. 66-3 Meeting, Albuquerque, N. Mex. pp. 1-6.

Some phreatophyte and riparian lands are useful for wildlife, erosion control, and recreation sites. Evaluations must be made to determine (1) the best economic use for the land, (2) whether water savings will justify expense for removing vegetation, and (3) what new problems of water rights might develop if increased water supply was produced through land management.

Hutchison, Boyd A.

A comparison of evaporation from snow and soil surface. Int. Ass. Sci. Hydrol. Bull. 11(1): 34-42, illus.

Spring evaporation from wet soil surfaces far exceeded that from surfaces of nearby patches of snow in forest openings in the central Rocky Mountains. No significant transfer of moisture from soil to snow occurred.

Hyder, D. N.,* Bement, R. E.,* Norris, J. J.,* and Morris, M. J.

Evaluating herbage species by grazing cattle. Part I. Food intake. Tenth Int. Grassland Congr. [Helsinki], Proc. 1966: 970-974.

Water-intake rates for European cattle were used to develop a method of estimating the amount of food eaten by cattle on range and pasture. Estimates by water intake were less variable than those obtained by herbage clipping.

Jameson, Donald A.

Competition in a blue grama-broom snakeweed-actinea community and responses to selective herbicides. J. Range Manage. 19: 121-124.

In a blue grama-broom snakeweed-Cooper actinea community, the presence of half-shrubs suppressed the growth of blue grama. Blue grama and forbs were increased when the half-shrubs were reduced by selective phenoxy sprays.

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Diurnal and seasonal fluctuations in moisture content of pinyon and juniper. U.S. Forest Serv. Res. Note RM-67, 8 pp., illus.

During summer, junipers had lowest moisture content at midday; pattern was reversed in winter. Pinyon did not show this regular diurnal pattern. Seasonal fluctuations were not well correlated with temperature, vapor-pressure deficit, soil moisture, or precipitation during individual storms.

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Juniper control by individual tree burning. U.S. Forest Serv. Res. Note RM-71, 4 pp., illus.

For 100 percent kill of juniper trees with individual tree burning, 60 percent of the crown should be scorched. The time required to achieve enough scorch increased with wind and tree size, but decreased with temperature.

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Pinyon-juniper litter reduces growth of blue grama. J. Range Manage. 19: 214-217, illus.

Tree litter was the major factor associated with reduction of blue grama in pinyon-juniper studies. Tree canopy had no influence on blue grama or, perhaps, was beneficial.

Johnson, W. M.

Effects of stocking rates and utilization on herbage production and animal response on natural grasslands. Tenth Int. Grassland Congr. [Helsinki], Proc. 1966: 944-947.

Three studies in which native vegetation was grazed throughout summer at different levels by beef cattle showed utilization in excess of 40-45 percent by

weight of the principal forage species resulted in undesirable changes in plant composition and lower forage production.

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Vegetative apomixis in Carex. J. Range Manage. 19: 305-306, illus.
Small, bulblike structures developed on a volunteer sedge (C. ebenea) seedling in a greenhouse. These structures, formed along culms, were easily detached, quickly sprouted roots when placed in water, and grew into new plants when placed in soil.

_____ and Smith, Dixie R.
Pot tests of productivity and nutritive status of three alpine soils in Wyoming. U.S. Forest Serv. Res. Note RM-75, 7 pp., illus.
Greenhouse tests showed alpine soils developed on quartzite till to be more fertile than those developed on volcanic ash or breccia. Phosphorus was limiting growth on till soils, and nitrogen was the limiting nutrient in ash and breccia soils.

Jones, John R.
A site index table for aspen in the southern and central Rocky Mountains. U.S. Forest Serv. Res. Note RM-68, 2 pp.
The spectrum of aspen habitats was sampled, and 177 mature aspen trees sectioned. Their individual height growth curves were used to construct nonharmonized, or natural, site index curves. The table represents height-age intercepts of the site index curves. Brief instructions are given for their use.

Koshi, Paul T.
Soil-moisture measurement by the neutron method in rocky wildland soils. Soil Sci. Soc. Amer. Proc. 30: 282-284, illus.
Several methods of installing access tubes for neutron soil-moisture measurements are described. Calibration curves and influence of rocks and voids on count rates are discussed.

Larson, M. M.
Racial variation in ponderosa pine at Fort Valley, Arizona. U.S. Forest Serv. Res. Note RM-73, 7 pp., illus.
Ponderosa pines from eastern and southeastern seed sources of the species range survived at Fort Valley, whereas trees of northern and western sources failed. In general, sources closest to Fort Valley grew best. Black Hills sources grew well in some instances.

Leaf, Charles F.
Free water content of snowpack in subalpine areas. West. Snow Conf. Proc. 34: 17-24, illus.
Summarizes observations made January 14-May 20, 1965, at Fraser Experimental Forest, Colorado: Temperature, density, cold content, and moisture deficit throughout snowpack; diurnal sequences of thermal quality in several layers of snowpack during snowmelt period; and coincident radiation and air temperatures.

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Sediment yields from high mountain watersheds, central Colorado. U.S. Forest Serv. Res. Paper RM-23, 15 pp., illus.
A study of annual sediment yields from one carefully logged and two undisturbed watersheds in the Fraser Experimental Forest showed good correlation between peak streamflow and accumulated sediment volume. The relationships indicate that a major part of the sediment load is derived from channel erosion. The effects of logging on sediment yields are discussed, and magnitude-frequency relationships are developed for estimating long-term sediment yields.

Lightle, Paul C.
Dwarfmistletoe reduces basal area growth of ponderosa pine in the Southwest. Phytopathology 56: 886-887.
Abstract of paper presented at annual meeting of American Phytopathological Society held in Denver, Colorado, August 1966.

Mace, Arnette C., Jr.
Accuracy of soil moisture readings with unsealed access tubes. U.S. Forest Serv. Res. Note RM-61, 2 pp.
Soil moisture was measured by the neutron-scattering technique in the White Mountains of Arizona in pairs of aluminum access tubes 2.5 feet apart. There were no significant differences in moisture readings between sealed and unsealed tubes.

Malechek, John C.
Cattle diets on native and seeded ranges in the ponderosa pine zone of Colorado. U.S. Forest Serv. Res. Note RM-77, 12 pp., illus.
Forage maturity at time of consumption was a major factor determining the general nutritive quality of range cattle diets. Cattle grazing seeded ranges in spring and fall had higher quality diets than cattle grazing native range yearlong, because seeded ranges started growth earlier in the spring and became dormant later in the fall.

Martin, S. Clark.
The Santa Rita Experimental Range. U.S. Forest Serv. Res. Paper RM-22, 24 pp., illus.
Research was begun in 1903 on the Santa Rita, south of Tucson, Arizona, to learn how to attain maximum sustained forage and beef production on semidesert range with reasonable costs. Results reported cover forage production, including dependence on perennial grasses, grazing management, and methods and advantages of controlling mesquite and other desirable plants.

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Will you see any game today? Progressive Agr. in Ariz. 18(4): 30-31, illus.
From incidental observations of game birds and animals on the Santa Rita Experimental Range south of Tucson, Arizona, it would not be unusual to walk a day or two over the semidesert range without seeing a mule deer or peccary, but 2 days without seeing a quail or rabbit would be discouraging.

_____, Barnes, Kenneth K.,* and Bashford, Leonard L.*
You can weigh a range cow before she knows it. Progressive Agr. in Ariz. 18(6): 8-9, illus.
An experimental scale for weighing range cattle was installed at the Santa Rita Experimental Range to force each individual animal to cross the scale platform on the way to water. Weight is recorded electrically, using strain-gage transducers and a strip-chart recorder. The system avoids the usual weight loss caused when cattle are disturbed by gathering, sorting, and weighing; weight changes can be related to weather or vegetation. The present model costs $3,000 to $4,000, and requires an operator, but refinements are being tested.

_____ and Ward, Donald E., Jr.
Using aerial applications, two annual sprays control mesquite. Progressive Agr. in Ariz. 18(4): 20-21, illus.
All mesquite control methods now in use require periodic followup. Aerial spraying with 2,4,5-T is no exception, but results from the Santa Rita Experimental Range near Tucson show that aerial spraying can be effective enough and lasting enough to be profitable. The first effective aerial mesquite control project cost $6.50 per acre for the two sprayings (in 1954 and 1955). Increases in grass production repaid the cost in 3 years. The job is now 12 years old.

Martinelli, M. Jr.

Avalanche technology and research--recent accomplishments and future prospects. Weatherwise 19: 232-239, 270-271, illus.

Discusses control techniques; points out prospects for better instrumentation for measuring stresses and metamorphic processes within snowpack, making nondestructive tests of physical and mechanical properties of snow, improving mountain weather forecasting, and studying avalanche motion; gives current avalanche classification system; and lists several references for additional reading.

_____ New snow-measuring instruments. Int Symp. Forest Hydrol. Proc. 1966: 793-796. Oxford & New York: Pergamon Press.

New instruments for measuring hydrological and strength and mechanical properties of snow are discussed briefly: Mt. Hood pressure pillow snow gage; neutron and gamma ray devices for measuring snow density, presence of ice lenses, and liquid water content of snow; determination of liquid water content of snow by freezing and by a plate capacitor; aerial snow-depth markers; snow resistograph; plastic replicas of snow and ice crystals; glide shoe; and photoelectric drift snow gage.

_____ Possibilities of snowpack management in alpine areas. Int. Symp. Forest Hydrol. Proc. 1966: 225-231, illus. Oxford & New York: Pergamon Press.

Operational procedures that appear to have some chance for success include (1) weather modification, especially seeding of orographic storms; (2) intentional avalanching to store snow in high-elevation, shaded valleys; (3) reshaping natural terrain features to improve their snow-trapping efficiency and capacity; (4) control of snowmelt by the addition of materials to the snow surface; and (5) snow fences or other artificial wind barriers to increase the amount of snow in areas of natural accumulation or to help shape terrain for more efficient snow storage.

_____ and Davidson, K. D.*

An example of damage from a powder avalanche. Int. Assoc. Sci. Hydrol. Bull. 11(3): 26-34, illus.

A powder avalanche moved a 3,200 kg. truck 19.8 m. horizontally, and dropped it 15.2 m. into a gully without serious damage. Data from the site are used to compute the velocity of snow-free air and of a snow-air mixture necessary to cause this event. These velocities are found to be within the velocity of the avalanche as estimated from the equations published by A. Voellmy.

Massey, Calvin L.

The genus Acrostichus Rahm 1928, synonym Diplogasteritus Paramonov 1952 (Nematoda). Helmin. Soc. Wash. Proc. 33: 8-13, illus.

Several new combinations are made within the genus Acrostichus. The synonyms of each species within the genus are recorded. Species in the genus had been previously described within the following genera: Diplogaster, Diplogasteritus, Diplogasteriana, Diplogastrellus, Fuchsia, and Mikoletzkya.

_____ The genus Mikoletzkya (Nematoda) in the United States. Helmin. Soc. Wash. Proc. 33: 13-19, illus.

Four new species of Mikoletzkya are described. All are associates of bark beetles. Previously described species, with three exceptions, are European in origin. Four new species described are M. inedia, M. tomea, M. diluta, M. ruminis.

_____ The influence of nematode parasites and associates on bark beetles in the United States. Ent. Soc. Amer. Bull. 12: 384-386.

Discusses past research in the United States; gives data on effect of nematodes on beetles and the role they play in ecology of these insects; and emphasizes further research needs.

_____ The nematode parasites and associates of Dendroctonus adjunctus (Coleoptera:Scolytidae) in New Mexico. Ent. Soc. Amer. Ann. 59: 424-440.

Parasitylenchus stipatus and Parasitaphelenchus dendroctoni, internal parasites of Dendroctonus adjunctus Blandford, are described and illustrated. The host is a primary pest of ponderosa pine in the Southwest. Twenty-five other nematode species were found associated with D. adjunctus; 16 are merely listed, 9 are described and illustrated as new.

Myers, Clifford A.

Height-diameter curves for tree species subject to stagnation. U.S. Forest Serv. Res. Note RM-69, 2 pp.

Relationships between tree heights and diameters in even-aged stands of ponderosa and lodgepole pines can be expressed by the equation $H = a + b \log D$.

_____ Yield tables for managed stands with special reference to the Black Hills. U.S. Forest Serv. Res. Paper RM-21, 20 pp., Illus.

Presents procedures for deriving yield tables for managed stands from data obtained on temporary plots. Yield tables for Black Hills ponderosa pine are given as examples of procedure.

Pase, Charles P.

Grazing and watershed values of native plants. In Native plants and animals as resources in arid lands of the southwestern United States. Amer. Ass. Advance. Sci., Rocky Mountain and Southwest. Div. Comm. on Desert and Arid Zones Res. Contrib. 8, 1965: 31-40.

Grazing and watershed values of plants characteristic of nine major plant communities are described. Problems of water yield and sediment production are considered for each type. Forage value of dominant shrubs and herbaceous plants are reported where known.

Patton, David R., and Hall, John M.*

Evaluating key areas by browse age and form class. J. Wildlife Manage. 30: 476-480, illus.

Key areas on game range can be evaluated by browse age and form class. Method consists of a score card whereby browse condition (good, fair, or poor) and trend (up, stable, or down) are determined from a summary of plant age and form class. By assigning values (5, 10, or 15 points) to each condition and trend class, then summing points, browse on the key area can be expressed as excellent (30), good (25), fair (20), poor (15), or very poor (10).

Peterson, Glenn W.

Penetration and infection of Austrian and ponderosa pines by Dothistroma pini. Phytopathology 56: 894-895.

Abstract of paper presented at annual meeting of American Phytopathological Society held in Denver, Colorado, August 1966.

_____ Western X-disease virus of chokecherry: Transmission and seed effects. U.S. Agr. Res. Serv. Plant Dis. Rep. 50: 659-660.

Though no evidence was obtained that this virus is transmitted through the seed, seeds for nursery production should not be collected from infected trees since only a low percentage will germinate.

Read, Ralph A.

Ten-year growth of two sources of large grade ponderosa pine transplants in Nebraska. U.S. Forest Serv. Res. Note RM-70, 3 pp., illus.

In a 10-year-old plantation of ponderosa pine in north-central Nebraska, the large grade 2 +1 stock from a Rosebud seed source grew faster than the same size and age class from a Niobrara seed source. Large grade stock of both seed sources survived better and grew faster than ungraded bedrun stock.

Reid, Elbert H.

Increasing forage production on rangelands in the southern Rocky Mountain region of western United States. Tenth Int. Grassland Congr. [Helsinki], Proc. 1966: 864-867.

Better management offers the greatest potential for increasing production on rangelands of the Rocky Mountain region. Proper stocking for 17 years gave three times the forage production as heavy stocking. A 60 percent grazing capacity increase in 7 years resulted from deferring grazing during the growing period in alternate years.

Reid, V. H.,* Hansen, R. M.,* and Ward, A. L.*

Counting mounds and earth plugs to census mountain pocket gophers. J. Wildl. Manage. 30: 327-334, illus.

New sign (mounds and earth plugs) appearing in a 2-day interval and numbers of mountain pocket gophers were counted on 54 plots, each containing 40,000 square feet, during every fall of a 3-year period. A significant positive correlation had utility for approximating gopher populations.

Reynolds, Hudson G.

Abert's squirrels feeding on pinyon pine. J. Mammal. 47: 550-551.

Abert's squirrel (Sciurus aberti Woodhouse) was observed feeding on pinyon pine (Pinus edulis Engelm.). This observation helps to explain isolated occurrences of Abert's squirrel, and suggests maintenance of borders of pinyon pine around clumps of ponderosa pine for habitat preservation of this squirrel.

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Slash cleanup in a ponderosa pine forest affects use by deer and cattle. U.S. Forest Serv. Res. Note RM-64, 4 pp.

Greater numbers of cattle droppings and fewer deer pellet groups were associated with slash-cleared areas. Neither amount nor composition of forage explains the differences in animal preference.

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Use of openings in spruce-fir forests of Arizona by elk, deer, and cattle. U.S. Forest Serv. Res. Note RM-66, 4 pp., illus.

Cattle use natural openings (but not created openings) more than adjacent forest; elk use the two situations about the same; deer use adjacent forests, particularly borders, more. Minimum cover for deer and elk is 10-15 acres. Maintenance of natural openings, and creation of small openings (less than 20 acres), is recommended for deer and elk habitat improvement.

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Use of a ponderosa pine forest in Arizona by deer, elk, and cattle. U.S. Forest Serv. Res. Note RM-63, 8 pp., illus.

Cattle used all sizes of forest openings; deer and elk preferred openings less than 1,600 feet across. Cattle and elk seemed to prefer perennial grasses; deer preferred forbs.

Riffle, Jerry W., and Lucht, Donald D.*

Root-knot nematode on ponderosa pine in New Mexico. U.S. Agr. Res. Serv. Plant Dis. Rep. 50: 126, illus.

Decline and mortality of a group of ponderosa pines in southwestern New Mexico was attributed to combined feeding of nematodes and white grubs. Believed to be the first report of root-knot nematodes on ponderosa pines.

Sander, D. H.

Effect of urea and urea-formaldehyde on the growth of lodgepole pine seedlings in a nursery. U.S. Forest Serv., Tree Planters' Notes 79, pp. 18-23, illus.

Rototilling urea-form and urea nitrogen into the seedbed prior to seeding was found to be an inefficient method of applying nitrogen to lodgepole pine seedlings. A liquid urea top dressing of 100 pounds of nitrogen per acre the second growing season resulted in seedling characteristics equal to 400 to 560 pounds of rototilled urea-form nitrogen per acre. Seedling caliper was significantly related to seedbed density and amounts of applied nitrogen.

Scharpf, Robert F.,* and Hawksworth, Frank G.

Hosts and distribution of Uredo phoradendri. Mycologia 58: 811-812.

Summarizes existing information on this rare rust of mistletoes (Phoradendron spp.) in western United States and Mexico.

Short, Henry L.,* Dietz, Donald R., and Remmenga, Elmer E.*

Selected nutrients in mule deer browse plants. Ecology 47: 222-229, illus.

Normal and predictable variation in plant chemistry caused by seasonal changes in plant phenology and physiology has important implications to the nutrition and physiology of deer.

Slabaugh, Paul E.

Shelterbelt research carried forward at [Bottineau] station. Bismarck N. Dak. Tribune (Conservation Section), 93 (Oct. 31): 13, illus.

Bottineau Shelterbelt Laboratory, started by U.S. Forest Service in 1931, does shelterbelt establishment and management studies for Northern Great Plains. Additional research is needed for revegetation of lignite spoil piles, specifications for shelterbelt planting on irrigated lands, and designs for recreation, highway, and other beautification plantings.

Smith, Dixie R.

Pot test of nutritive status of two high elevation soils in Wyoming. J. Range Manage. 19: 38-40, illus.

Pot tests of two high altitude soils showed them to be deficient in available phosphorus. Protection from grazing for 20 years did not increase their productive capability as measured in this study.

_____ and Alley, Harold P.*

Chemical control of alpine avens. J. Range Manage. 19: 376-378, illus.

Both 2,4-D and 2,4,5-T at 1, 2, and 3 pounds per acre gave about 98 percent control. By the third growing season, grasses filled voids left by avens and forbs.

Springfield, H. W.

Effects of 3 years' grazing at different intensities on crested wheatgrass lambing range in northern New Mexico. U.S. Forest Serv. Res. Note RM-65, 7 pp., illus.

Production of crested wheatgrass apparently was unaffected by intensity of use (39 to 84 percent) during the study. Yields varied from 400 to 1,565 pounds per acre, however, with winter-spring precipitation. Stands grazed most heavily were deteriorating at the end of the study.

_____

Germination of fourwing saltbush seeds at different levels of moisture stress. Agron. J. 58: 149-150, illus.

Moisture stress decreased germination, but there was a strong temperature effect. Germination was better at 63° F. than at 49° F. or 85° F. at higher levels of moisture stress.

Spencer, John S., Jr.*
Arizona's forests. U.S. Forest Serv. Resource Bull. INT-6, 57 pp., illus.
First comprehensive inventory of Arizona's 21 million acres of forests shows 27 billion board feet of sawtimber volume on the 4 million acres of commercial area; presents statistics on area, volume, growth, mortality, and timber use; describes species, volumes per acre, stocking, site quality, ownership, trends in product harvesting, and other factors that bear on timber management; discusses significant factors affecting future development--timber stand improvement, industry problems, roads, fire protection, and the role of research.

Staley, John M.
Identity of a needlecast fungus attacking Mexican pines. Phytopathology 56: 903.
Examination of the type collection of Hypoderma mexicanum Wolf indicates need for changes in the original description. New hosts for the fungus are Pinus cooperi, P. durangensis, and P. engelmannii. Abstract of paper presented at annual meeting of American Phytopathological Society held in Denver, Colorado, August 1966.

Stelzer, Milton J.
Diatomaceous earth tested against spruce budworm. J. Econ. Ent. 59: 744-745.
Although treatments reduced insect numbers significantly, reductions were not great enough to suppress an outbreak or reduce degree of defoliation.

Swanson, Robert H.
Seasonal course of transpiration of lodgepole pine and Engelmann spruce. Int. Symp. Forest Hydrol. Proc. 1966: 417-433, illus. Oxford & New York: Pergamon Press.
Heat transport as an indicator of sap velocity showed that (1) transpiration takes place throughout the year; (2) length of transpiring day varies with season and species; (3) transpiration varies from day to day in spring, summer, and fall in response to weather; (4) water within the stem available for loss via the leaves varies with season; and (5) little sap movement occurs in the outermost 5 to 10 years' growth of xylem tissue.

_____ and Lee, Richard.
Measurement of water movement from and through shrubs and trees. J. Forest. 64: 187-190, illus.
Plant transpiration can be estimated by (1) measuring vapor production in a clear, plastic tent, (2) weighing excised plant parts to determine rate of water loss, and (3) measuring sap velocity, and relating it to factors affecting transpiration. Advantages and disadvantages are compared.

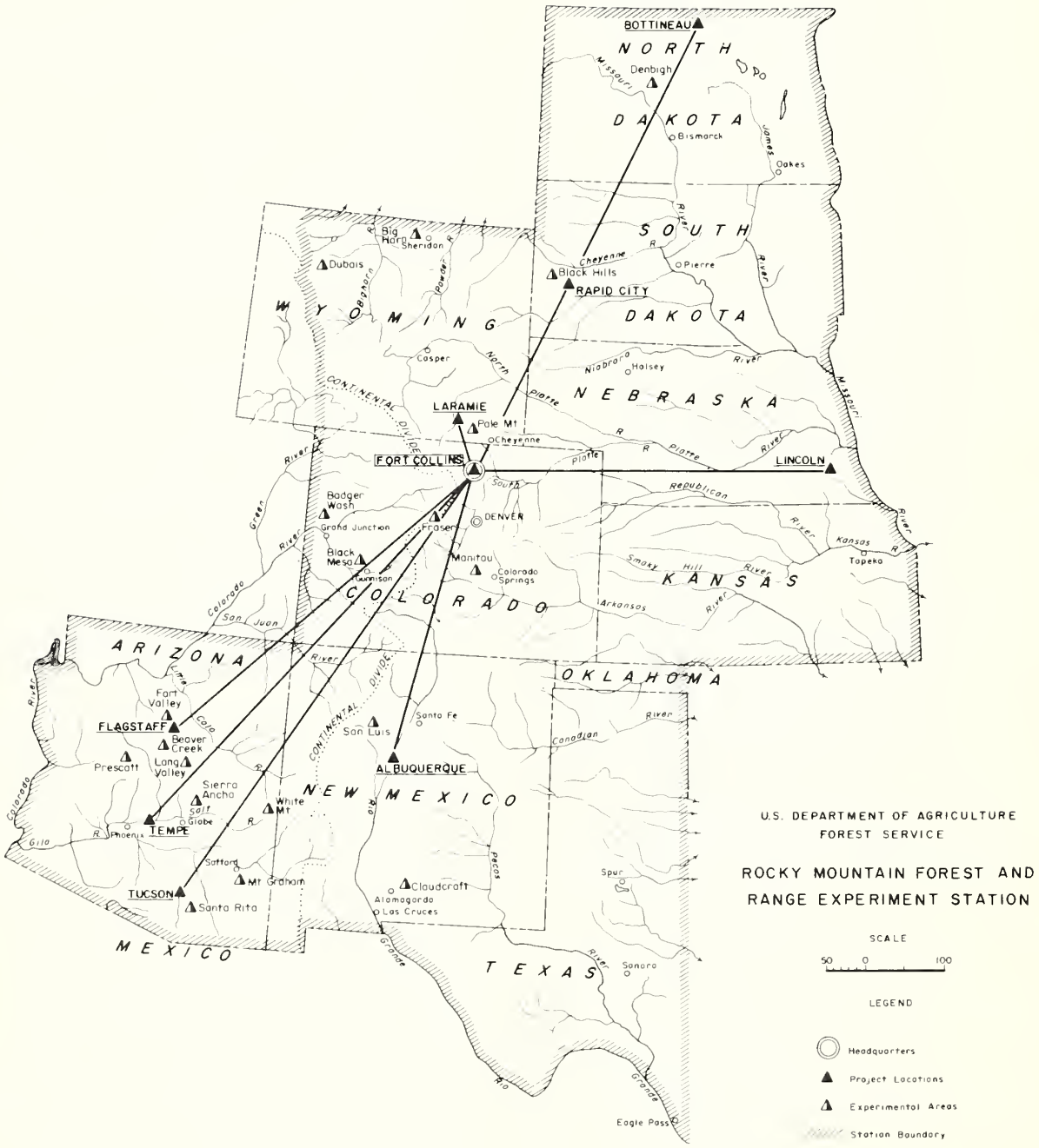
Thilenius, John F.
An improved vegetation sampling quadrat. J. Range Manage. 19: 40.
An open-end quadrat mounted on a vertical staff increases speed and efficiency of measurement when large numbers of small plots are used for measuring frequency, density, or coverage of rangeland vegetation.

Van Haverbeke, David F.
Don't choke your shelterbelt evergreens. Nebr. Agr. Exp. Sta. Quart. 13(3): 12-13, 28, illus.
Evergreen trees in old Prairie States Forestry Project shelterbelts in Nebraska, released 5 years ago, have shown remarkable ability to recover from years of suppression and crowding. They should be released as quickly as possible since there is a limit as to how long they can maintain themselves in an overcrowded environment.

Worley, David P.
Economic evaluation of watershed management alternatives--the Beaver Creek watersheds. N. Mex. Water Conf. Proc. 11: 58-65, illus.
Beaver Creek pilot watersheds were established (1) to measure and evaluate effects of management practices, intended to increase streamflow, upon water supply, sediment, timber and forage production, wildlife populations, and recreational use of watershed lands; and (2) to formulate concepts and processes for economic evaluation of alternative watershed management practices, and develop guides for making multiple-use management decisions.

Wysong, David S.,* and Peterson, Glenn W.
Known distribution of Dutch elm disease in Nebraska, 1965. U.S. Agr. Res. Serv., Plant Dis. Rep. 50: 618.
Dutch elm disease, first found in Nebraska in 1960, was found in 44 communities in 1965, including Omaha, Lincoln, Grand Island, and Hastings.

Yerkes, Vern P.
Weight and cubic-foot relationships for Black Hills ponderosa pine saw logs. U.S. Forest Serv. Res. Note RM-78, 4 pp., illus.
Green weight per cubic foot of 223 Black Hills ponderosa pine logs was significantly correlated with selected variables. Log green weight per cubic foot and cubic foot volumes were predicted for individual logs using selected variables and weight.


BOTTINEAU
NORTH
DAKOTA
Denbigh
Bismarck
James
Oakes
SOUTH
DAKOTA
Pierre
RAPID CITY
Black Hills
Cheyenne
WYOMING
Big Horn
Sheridan
Dubois
Casper
NEBRASKA
Niobrara
Halsey
LARAMIE
Pole Mt
Cheyenne
FORT COLLINS
LINCOLN
Platte
Republican
Kansas
Topeka
Smoky Hill
KANSAS
DENVER
Badger Wash
Grand Junction
Fraser
Black Mesa
Gunnison
Manitou
Colorado Springs
COLORADO
Arkansas
ARIZONA
OKLAHOMA
Fort Valley
FLAGSTAFF
Beaver Creek
Prescott
Long Valley
Sierra Ancha
Salt
Globe
White Mt
TEMPE
Phoenix
Gila
Safford
Mt Graham
TUCSON
Santa Rita
Santa Fe
San Luis
ALBUQUERQUE
NEW MEXICO
Canadian
Claudcroft
Alamogordo
Las Cruces
Pecos
Spur
Sonora
TEXAS
Eagle Pass
MEXICO
Rio Grande
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
ROCKY MOUNTAIN FOREST AND
RANGE EXPERIMENT STATION
SCALE
50 0 100
LEGEND
Headquarters
Project Locations
Experimental Areas
Station Boundary

COMMON AND BOTANICAL NAMES OF ANIMALS AND PLANTS MENTIONED

ANIMALS

Birds

Flycatcher, Hammond's	*Empidonax hammondi* (Xantus)
Flycatcher, western	*Empidonax difficilis difficilis* Baird
Mallard	*Anas platyrhynchos platyrhynchos* Linnaeus
Peewee, western wood	*Myiochanes richardsoni richardsoni* Swainson
Turkey, Merriam's	*Meleagris gallapavo merriami* Nelson

Mammals

Deer, mule	*Odocoileus hemionus hemionus* (Rafinesque)
Deer, white-tailed (Arizona)	*Odocoileus virginianus couesi* (Coues & Yarrow)
Deer, white-tailed (South Dakota)	*Odocoileus virginianus dacotensis* Goldman & Kellogg
Elk	*Cervus canadensis canadensis* (Erxleben) Reynolds
Mouse, Apache pocket	*Perognathus apache* (Merriam)
Mouse, deer	*Peromyscus maniculatus* (Wagner)
Mouse, desert harvest	*Reithrodontomys megalotis* (Baird)
Mouse, grasshopper	*Onychomys leucogaster* (Maximilian)
Mouse, piñon	*Peromyscus truei* (Shufeldt)
Packrat, desert	*Neotoma lepida* (Thomas)
Pocket gopher, northern	*Thomomys talpoides* (Richardson)
Rat, Ord kangaroo	*Dipodomys ordi* (Woodhouse)
Squirrel, white-tailed antelope	*Citellus leucurus* (Merriam)
Vole, meadow	*Microtus pennsylvanicus* (Ord)
Vole, montane	*Microtus montanus* (Peale)

PLANTS

Forbs

Actinea	*Hymenoxys* spp.
Agoseris	*Agoseris* spp.
Agoseris, pale	*Agoseris glauca* (Pursh) D. Dietr.
Burroweed	*Haplopappus tenuisectus* (Greene) Blake
Clover	*Trifolium* spp.
Dandelion	*Taraxacum* spp.
Dandelion, common	*Taraxacum officinale* Wiggers
Fleabane, aspen	*Erigeron macranthus* Nutt.
Geranium, Fremont	*Geranium fremontii* Torr.
Goldaster, hairy	*Chrysopsis villosa* (Pursh) Nutt.
Peavine, aspen	*Lathyrus laetivirens* Greene
Rockjasmine, western	*Androsace occidentalis* Pursh
Yarrow, western	*Achillea lanulosa* Nutt.

Grasses and Grasslike Plants

Bluegrass, big	*Poa ampla* Merr.
Bluegrass, Kentucky	*Poa pratensis* L.
Bristlegrass, plains	*Setaria macrostachya* H.B.K.
Cottontop, Arizona	*Trichachne californica* (Benth.)
Dropseed, pine	*Blepharoneuron tricholepis* (Torr.) Nash
Fescue, Arizona	*Festuca arizonica* Vasey
Fescue, Idaho	*Festuca idahoensis* Elmer
Fescue, Thurber	*Festuca thurberi* Vasey
Galleta	*Hilaria jamesii* (Torr.) Benth.
Grama, black	*Bouteloua eriopoda* Torr.
Grama, blue	*Bouteloua gracilis* (H.B.K.) Lag.
Junegrass, prairie	*Koeleria cristata* (L.) Pers.
Lovegrass, Lehmann	*Eragrostis lehmanniana* Nees
Needlegrass, Letterman	*Stipa lettermanii* Vasey
Muhly, mountain	*Muhlenbergia montana* (Nutt.) Hitchc.
Rushes	*Juncus* spp.
Sacaton, alkali	*Sporobolus airoides* Torr.
Sedges	*Carex* spp.
Wheatgrass, crested	*Agropyron cristatum* (L.) Gaertn.

Shrubs and Trees

Aspen, quaking	*Populus tremuloides* Michx.
Bitterbrush	*Purshia* spp.
Cercocarpus, birchleaf	*Cercocarpus betuloides* Nutt.
Cliffrose	*Cowania mexicana* D. Don
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Fir, corkbark	*Abies arizonica* (Merriam) Lemm.
Fir, white	*Abies concolor* (Gord. & Glend.) Lindl.
Hemlock, mountain	*Tsuga mertensiana* (Bong.) Carr.
Hemlock, western	*Tsuga heterophylla* (Raf.) Sarg.
Jojoba	*Simmondsia chinensis* (Link) Schneid.
Juniper, alligator	*Juniperus deppeana* Steud.
Juniper, one-seed	*Juniperus monosperma* (Engelm.) Sarg.
Juniper, Utah	*Juniperus osteosperma* (Torr.) Little
Manzanita, pointleaf	*Arctostaphylos pungens* H.B.K.
Mountainmahogany	*Cercocarpus montanus* Raf.
Oak, Gambel	*Quercus gambelii* Nutt.
Oak, shrub live	*Quercus turbinella* Greene
Pine, Austrian	*Pinus nigra* Arnold
Pine, bristlecone	*Pinus aristata* Engelm.
Pine, eastern white	*Pinus strobus* L.
Pine, lodgepole	*Pinus contorta* Dougl.
Pine, pinyon	*Pinus edulis* Engelm.
Pine, ponderosa	*Pinus ponderosa* Lawson
Pine, southwestern white	*Pinus strobiformis* Engelm.
Pine, western white	*Pinus monticola* Dougl.
Pinyon, Mexican	*Pinus cembroides* Zucc.
Rabbitbrush, Greenes	*Chrysothamnus greenei* (A. Gray) Greene
Rabbitbrush, Parry	*Chrysothamnus parryi* (A. Gray) Greene
Rabbitbrush, rubber	*Chrysothamnus nauseosus* (Pall.) Britt.
Sagebrush, big	*Artemisia tridentata* Nutt.
Saltbush, fourwing	*Atriplex canescens* James
Serviceberry	*Amelanchier* spp.
Silktassel, Wright	*Garrya wrightii* Torr.
Silktassel, yellowleaf	*Garrya flavescens* S. Wats.
Skunkbush	*Rhus trilobata* Nutt.
Snakeweed, broom	*Gutierrezia sarothrae* (Pursh) Britt. & Rusby
Spruce, Engelmann	*Picea engelmannii* Parry
Spruce, blue	*Picea pungens* Engelm.
Sumac, sugar	*Rhus ovata* S. Wats.